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Performance Intensity Functions for Digitally Recorded Japanese Speech Audiometry Materials

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PERFORMANCE INTENSITY FUNCTIONS FOR DIGITALLY RECORDED

JAPANESE SPEECH AUDIOMETRY MATERIALS

by

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GRADUATE COMMITTEE APPROVAL

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This thesis has been read by each member of the following graduate committee and by majority vote has been found to be satisfactory.

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As chair of the candidate's graduate committee, I have read the thesis of Tanya Crawford Mangum in its final form and have found that (1) its format, citations, and bibliographical style are consistent and acceptable and fulfill university and department style requirements; (2) its illustrative materials including figures, tables, and charts are in place; and (3) the final manuscript is satisfactory to the graduate committee and is ready for submission to the university library.

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ABSTRACT

PERFORMANCE INTENSITY FUNCTIONS FOR DIGITALLY RECORDED JAPANESE SPEECH AUDIOMETRY MATERIALS

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Department of Audiology and Speech-Language Pathology

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Abstract

The purpose of this study was to develop digitally recorded speech audiometry materials in the Japanese language to evaluate Speech Reception Threshold (SRT) and speech discrimination. Trisyllabic words were used to evaluate the SRT and bisyllabic words were used for speech discrimination. Words were recorded by one native female talker and one native male talker who were judged as having standard Japanese dialects. Twenty native Japanese speakers between the ages of 20 and 32 were used as subjects to evaluate 69 trisyllabic words across 13 different intensity levels. The 25 trisyllabic words with the steepest psychometric function (%/dB) were selected for inclusion in the final CD. The final trisyllabic words were digitally adjusted so that the threshold of each word was equal to the mean PTA (3.42 dB HL) of all the subjects. The mean psychometric function (%/dB) at 50% for the trisyllabic words was 9.6 %/dB for the

male talker and 7.7 %/dB for the female talker. The same 20 subjects were also used to evaluate 240 bisyllabic words across 10 different intensity levels. A logistic regression was used to obtain regression slopes for each of the 240 words. The 200 bisyllabic words with the steepest slope were selected for inclusion in the final CD. Four lists of 50 words each and eight half-lists of 25 words each were created from the selected bisyllabic words. A chi-square statistic revealed no significant differences among the lists or half-lists. The mean psychometric function at 50% for the bisyllabic lists and half-lists was 5.9 %/dB for the male talker and 5.2 %/dB for the female talker.

ACKNOWLEDGMENTS

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIXES

Appendix Page

Introduction

The world is becoming increasingly closer knit as technology and communication advance. Because of these advances many world languages are becoming more prominent in the United States, and many U.S. citizens are foreign-born or come from non-standard American English speaking homes (Ramkissoon, Proctor, Lansing, & Bilger, 2002). Audiologists are more frequently faced with testing individuals whose native language is not English. Audiologic testing typically includes speech reception threshold (SRT) and speech discrimination tests that require the patient to repeat words as they hear them at a suprathreshold level. This testing is less than ideal when recorded test materials are not available in the patient's native language. The purpose of this study was to develop speech audiometry materials in the Japanese language to assist audiologists with evaluating hearing capabilities in individuals whose native language is Japanese.

Speech Audiometry

Assessing a patient's ability to understand speech can be done informally as the audiologist talks with their patient. The process of assessing an individual's ability to hear speech is referred to as speech audiometry. "Historically, the first speech tests were spoken or whispered messages presented at measured distances between the talker and the listener. These tests provided a gross estimate of an individual's ability to hear speech" (ASHA, 1985, p. 85). More formalized tests have been developed to be used today. These tests include the SRT and speech discrimination. Speech audiometry materials developed in English should meet several criteria: (a) familiarity, (b) phonetic dissimilarity, (c) representative sample of English speech sounds, and (d) homogeneity with respect to audibility (Hudgins, Hawkins, Karlin, & Stevens, 1947). Similar criteria should be followed when developing speech audiometry materials in other languages.

Speech Reception Threshold

The SRT is a tool used in audiology because it (a) establishes the relationship between speech and pure-tone sensitivity, (b) establishes a reference intensity level for speech discrimination testing at suprathreshold levels, and (c) is utilized in auditory research to assess ear sensitivity to speech signals under a variety of listening conditions (Young, Dudley, & Gunter, 1982). Significant differences between the patient's SRT and pure-tone average are of clinical importance (Gelfand, 2001). The threshold for speech can mean one of two things, either the level that speech is just audible or the level at which speech is just intelligible. SRT is defined by ASHA as "the minimum hearing level for speech (see American National Standards Institute (ANSI) S3.6-1996 standard or subsequent superseding standards) at which an individual can recognize 50% of the speech material" (1988, p. 96). The speech detection threshold is the lowest level that a speech signal can be detected 50% of the time (Gelfand, 2001).The difference between SRT and speech detection is that speech detection only requires the patient to identify the presence of speech 50% of the time where the SRT requires the patient to correctly repeat speech 50% of the time. An audiologist generally identifies a patient's SRT by having them repeat spondaic words, or two-syllable words with equal emphasis placed on each syllable (i.e. *baseball* or *ice cream*; ASHA, 1988). Spondaic words are used because very small increases in presentation level result is a large change in percentage correct recognition (Gelfand, 2001).

There are two general types of stimuli used to find a patient's SRT: monitored live voice, where the audiologist speaks into a microphone and monitors their vocal level on the audiometer's VU meter (Gelfand, 2001), or recorded materials. The use of recorded materials is the preferred method (ASHA, 1988). The recorded list that is most commonly used to measure the SRT is the Central Institute for the Deaf (CID) Auditory Test W-1 (Martin & Forbis, 1978).

Development of SRT materials. "It was discovered that the class of words having the highest homogeneity contained those disyllables spoken with equal stress on both syllables. These words are called spondees" (Egan, 1948, p. 965). The spondaic word lists for SRT evaluation were initially developed at the Harvard Psychoacoustic Laboratory (PAL) by Hudgins, Hawkins, Karlin, and Stevens in 1947 (Gelfand, 2001; Hudgins et al., 1947). During World War II military personnel needed a way to test the intelligibility of military communication devices. The Harvard PAL Auditory Tests No. 9, which tests the threshold of hearing for words, and Test No. 12, which tests the threshold of hearing for sentences were made available for clinical use by recording them on phonograph records. The Harvard PAL 9 and 12 tests were improved by Hirsh et al.(1952) at the CID. Hirsh et al. reported that the CID Auditory Test W-2 (spondees at descending levels) is an improved version of the PAL Auditory Test No. 9 and CID Auditory Test W-1 (spondees at constant level) is a modified version of PAL Auditory Test No. 14. The CID auditory tests W-1 and W-2 used 36 of the most familiar spondaic words from the original Harvard PAL tests words.

Choice of stimuli. In a study by Robinson and Koenigs (1979) monosyllabic digits (*one, two, three, four, five, six, eight,* and *nine*) were used to find a patient's SRT.

Digits were chosen because they are highly familiar and are easily recognized by a wide range of individuals, including young children, the elderly, those with profound hearing losses, and those with limited English abilities (Ramkissoon et al., 2002; Robinson & Koenigs, 1979). Robinson et al. concluded that the use of digits and/or a descending pattern of presentation resulted in a lower SRT then spondaic words, which they recommend.

ASHA (1977) published guidelines for determining the SRT which specified that spondaic words are the recommended test material for determining speech threshold. The use of spondaic words for obtaining the SRT was reaffirmed by ASHA (1988) when the guidelines were updated. Spondaic words have been proven to be the best stimuli comparable to speech thresholds obtained using sentences (Carhart, 1946).

Speech Discrimination

Often times patients comment that they can hear speech but they are unable to understand it. The speech that they do hear is lacking intelligibility. This frequently occurs due to cochlear lesions impairing speech clarity. The patient's speech cues are distorted and attenuated. Speech discrimination scores give audiologists information on how well a patient hears and identifies words at a specific intensity level (Katz, 2002).

Speech discrimination is a suprathreshold test used to measure speech intelligibility at suprathreshold levels. Speech discrimination testing has been developed so that it "(1) is reliable on test-retest measurements; (2) separates normal from hearing-impaired patients; and further, (3) separates patients with different types and etiologies of hearing loss" (Northern, 1984, p. 19). Speech discrimination is typically evaluated using PAL PB-50, CID W-22 or Northwestern University Auditory Test #6 (Martin &

Forbis, 1978; Hirsh et al., 1952). Many of the lists used for speech discrimination testing consist of 50 words that are phonetically balanced (PB) in order to represent the frequency of occurrence of phonemes that occur in everyday English (Northern, 1984). The Harvard PAL PB-50 was the first PB lists to attain wide clinical use (Gelfand, 2001). The PAL PB-50 lists were modified by Hirsh et al. at the CID and replaced with the CID W-22. The CID W-22 has 200 words in 4 lists of 50 words each and each list has been recorded with 6 different randomizations. About 95% of the words used in the CID W-22 were from Thorndike's (1932) 4,000 most common words. At the time of publication of the CID W-22 test the researchers printed a footnote saying "Experience to date indicates… that W-22 does not satisfactorily separate patients with mixed deafness from patients with pure conductive deafness" (Hirsh et al., 1952, p. 335). In spite of this warning the CID W-22 stimuli have been used clinically for years to assess speech discrimination ability.

Generally speech discrimination test scores are useful and able to separate those with normal hearing and conductive hearing losses from those with cochlear hearing impairments. The NU-6 test was created in 1966 and has 4 lists of 50 phonemically balanced words based on Lehiste and Peterson's (1959) work discussing the differences between phonemically balanced and phonetically balanced words. Phonetically balanced word lists contain the actual distribution of sounds as they occur in average speech. This is a wonderful idea, however speech sounds vary depending on the surrounding sounds and phonetically balanced word lists are therefore impossible to accomplish. Word lists that follow a consonant-vowel-consonant (CVC) pattern are referred to as phonemically balanced (Martin, Champlin, & Perez, 2000). The NU-6 uses 1263 monosyllabic words from Thorndike and Lorge (1944) word count. The words in the NU-6 test were all of a CVC form which also differed from the Harvard PAL PB-50 and the CID W-22 materials. The NU-6 and CID W-22 both are open set tests of 50-words. The words are reasonably familiar monosyllabic words which are phonemically balanced within the lists.

When obtaining speech discrimination scores typically each ear is tested separately with PB monosyllabic word lists (Katz, 2002). Phonetically balanced lists played a major role as speech discrimination tests were being developed, however Gelfand (2001) reports that several researchers have found that use of phonetic balance tests have little impact on testing outcomes.

Testing Non-Native English Speakers

When an audiologist is testing an individual whose native language is something other than standard American English there are several options. Audiologists frequently modify the SRT procedure by using a subset of the stimuli to familiarize the patient with the words (Ramkissoon et al., 2002). By reducing the set size audiologists obtain more sensitive SRTs which show that the individual's speech reception is better than it really is. Using English digits is another option. Non-native English speakers in the United States are usually familiar enough with English digits to perform successfully using digits (Ramkissoon et al., 2002). There is also a multimedia approach that uses auditory/visual speech materials that are designed to estimate the word-recognition ability of Spanish speakers (McCullough, Wilson, Birck, & Anderson, 1994). The auditory portion of the multimedia approach is administered typically in the client's native language accompanied by four to six pictures or written words with one representing the target word. The testing occurs through the use of a computer. A fourth approach is to use recorded speech audiometry materials in the patient's native language. This ensures the client's understanding and familiarity with the test stimuli. Unfamiliar words are more difficult to identify than familiar words, therefore tests that use materials which are familiar only to native English speakers could put non-native English speakers at a disadvantage (Danhauer, Crawford, & Edgerton, 1984). There is a need to continue to develop materials in other languages so non-English speaking individuals are not placed at such a disadvantage.

Japanese Speech Audiometry

A Compact Disc (CD) distributed by Audiology Japan in 1995 contains 17 tracks used for testing Japanese speakers. Tracks 1 and 11 contain a 1 kHz calibration tone. Tracks 2 and 12 begin with the testing instructions followed by 6 sets of numbers. The individual being tested is instructed to write down the numbers they hear and told that each set of numbers will become a little quieter. Tracks 3-10 and 13-17 contain many of the sounds used in Japanese and the client is instructed to write down the sound they hear. These sounds are monosyllabic nonsense syllables having no meaning. The Audiology Japan CD contains 2 sets of sounds. The first set uses 20 sounds which are also included in the second set's 50 sounds. Not all of the sounds in the Japanese language are covered in this test.

Sunayama (2003) reports the different tests she uses when evaluating client's hearing. Sunayama has 10 different types of tests including language tests (SRT using numbers and sounds, distortion of SRT words, different words in each ear, and different sounds in each ear). When Sunayama and other audiologists in Japan test hearing using language tests, they use numbers and sounds very similar to the ones contained on the Audiology Japan Sound Hearing Test CD.

In the late 1970s researchers began developing a Japanese staggered spondaic word (SSW) test to be used to evaluate central auditory function (Rudmin, 1979). Rudmin’s final tapes included 40 test items with each word having 4 syllables. Rudmin reported that further studies needed to be considered before these materials are used clinically.

Influential Factors on Speech Audiometry Performance

Word selection and familiarity. It has been found that the more familiar a patient is with the words being presented to them the better their performance in speech discrimination. Unfamiliar words are more easily missed (Danhauer et al., 1984; Egan, 1948). Hudgins et al. (1947) identified four basic criteria they felt were essential for speech audiometry materials; the first of these was familiarity. They reported that the object of the test is to measure the threshold of intelligibility for speech, not to test vocabulary or intelligence; therefore it is essential that the test materials being used be as simple and familiar as possible while still meeting the requirements imposed by his other criteria listed.

ASHA (1988) guidelines for testing SRT strongly recommend familiarizing patients with words before testing. By familiarizing the patient with the test words the audiologist ensures that the patient (a) knows the words used for testing, (b) can auditorily recognize and make responses to each word, and (c) patient’s responses can be accurately recorded. However many audiologists report that they do not familiarize patients with testing materials (Martin & Forbis, 1978; Martin, Champlin, & Chambers, 1998). The difference between audiologists who familiarize their patients with the test material and those who do not is very minimal, however a majority of audiologists do not familiarize their patients with test material before performing SRT tests (Martin & Forbis, 1978).

Carrier phrases. The use of carrier phrases, e.g. “You will say…” or “Say the word…” are commonly found and have become somewhat controversial. A carrier phrase was originally used to ensure that the last word of the carrier phrase reaches 0 dB on the VU meter and the test words are conveyed with equal stress (Martin, Hawkins, & Bailey, 1962). This is particularly important when the test words are being presented through the use of monitored live voice (MLV).

Egan (1948) reported that the use of a carrier phrase was desirable for several reasons which included: (a) preparing the listener for the test item, (b) reducing variability when using carbon-button microphones, and (c) allowing the speaker to modulate their voice to keep it constant and even. Carrier phrases have been commonly used and allow the test to be administered in a more continuous speech-like manner. Many researchers apply the use of carrier phrases in their work. Hudgins et al. (1947) included the use of the carrier phrase “Number one”, “Number two”, etc. during their study on measuring hearing loss. Gelfand (1976) concluded that carrier phrases should be used when using MLV.

Martin and Forbis (1978) reported that more than 49% of correspondents they contacted reported that they do not use a carrier phrase for SRT testing. They also reported that the use of the carrier phrase “You will say…” has become much less popular and audiologist are using it less and less for SRT and speech discrimination testing. Martin, Champlin, and Chambers (1998) conducted a survey of 218 audiologists who are members of the American Academy of Audiology. Their survey reported that the majority of audiologists surveyed (57%) do not present spondees with a carrier phrase and found that only 36% use the phrase "Say the word…" before each word presented.

Carrier phrases can, however, confuse some patients as well as increase the length of the testing process (Martin et al., 1962). Normal hearing individuals as well as those with a conductive-loss preferred not to have the carrier phrase used, and the results showed that their speech discrimination scores were not affected by using or not using a carrier phrase (Martin et al., 1962). The use of carrier phrases is not essential. Some researchers have found them to be helpful (Egan, 1948; Gelfand, 1975) while others find them to make no difference (Martin et al., 1962).

Method of presentation. When testing SRT the test words may be presented in one of two ways; MLV or using recorded materials. This is seen as very controversial among audiologists and both have advantages and disadvantages (Hirsh, 1947). When MLV is used the audiologist speaks into a microphone while monitoring their voice on the VU meter. Katz (2002) reports that each syllable of a spondee should be presented at 0 VU (±3 dB) on the VU meter.

Presentation of speech stimuli using MLV is seen as effective by many researchers (Carhart, 1946) and the majority of audiologist report using MLV over recorded material (Gelfand, 2001; Hurley & Sells, 2003; Jerger, 1987; Martin et al., 1998). Audiologists state that the conventional recorded speech discrimination "takes too much time" when looked at from a clinical stand and the demands on their schedule

(Hurley & Sells, 2003). ASHA has stated in both the 1977 and 1988 guidelines that use of recorded materials is the preferred method of presentation however, MLV is also seen as acceptable (Gelfand, 2001; Hirsh, 1947). When the audiologist is dealing with patients who do not speak the same language then using MLV becomes much more difficult. Prerecorded materials are much better controlled and the quality of presentation can be ensured (ASHA, 1988; Hirsh, 1947).

Audiologists decide which test to use and which form (live/recorded, male/female) to use for testing. Katz (2002) recommends that limitations such as age, physical condition, mental abilities, educational level, and speech and/or language problems should be taken into account by the audiologist when deciding which speech discrimination test and form to use with a particular patient.

Type of recording. Materials that are digitally recorded provide several advantages over analogue recordings. By using a CD system the problems that are caused with the analogue systems are eliminated, the digital signal cannot be degraded as it can with analogue. Other advantages to digital recordings are channel separation, greater dynamic range, reduced harmonic distortion, improved signal-to-noise ratio, and a longer storage life without degradation (Ridgway, 1986). When using a CD the audiologist is able to go directly to the desired track as well as play the stimuli in any order they choose. Because CDs use a laser to read the information, the CD itself as well as the quality of the sound will not degrade as it is played time and time again (Ridgway, 1986). These improvements greatly improve the quality of recorded materials, making CDs the preferred method of recording over analogue tapes.

In summary, many things need to be taken into consideration when developing speech audiometry materials. The familiarity of the words chosen is important so that the individuals being tested will not be placed at a disadvantage (Danhauer et al., 1984; Egan, 1948; Hudgins et al., 1947). How the word lists are to be presented and recorded also needs to be taken into consideration. The use of recorded materials instead of MLV is recommended by ASHA as well as other researchers (ASHA, 1988; Hirsh, 1947). When researchers record materials it is advantageous to record them onto compact discs instead of tapes or even records as was previously mentioned (Ridgway, 1986).

Brigham Young University has produced digitally recorded SRT and speech discrimination materials in many different languages. These lists were formed by identifying frequently used words, digitally recording the words in an anechoic chamber, and collecting normative data having subjects listen to the words at a number of different intensity levels. To date speech audiometry materials have been developed at BYU in Spanish (Christensen, 1995)**,** Italian (Greer, 1997), Brazilian Portuguêse (Harris, Goffi, Pedalini, Gygi, & Merrill, 2001; Harris, Goffi, Pedalini, Merrill, & Gygi, 2001), Polish (Harris, Nielson, McPherson, Skarzynski, & Eggett, 2004a; Harris, Nielson, McPherson, Skarzynski, & Eggett, 2004b), French (Nelson, 2004), Russian (Pola, 2003), and Korean (Harris, Kim, & Eggett, 2003a; Harris, Kim, & Eggett, 2003b). Audiologic test materials in the Japanese language are limited and continued work is needed in developing them (Rudmin, 1979).

Presently, Japan does not have any recorded speech audiometry materials using words. The testing material used by audiologists in Japan consists of a CD where the patient listens to and writes down numbers and sounds with no meaning (Audiology

Japan, 1995). The purpose of the present investigation was to aid in the further development of Japanese speech audiometry materials. This project was designed to identify commonly used bisyllabic and trisyllabic words in the Japanese language, to identify both a male and female talker from Japan to record the selected words, to create word lists for evaluating the SRT, to create 4 speech discrimination lists of 50 words each and 8 half-lists of 25 words each, and to obtain normative data on the SRT and speech discrimination word lists.

Method

Subjects

A total of 20 native Japanese subjects (4 male & 16 female) participated in the evaluation of the Japanese trisyllabic and bisyllabic words. Subjects ranged in age from 20 to 32 years (M = 25.5 years). Each subject had pure-tone air-conduction thresholds ≤15 dB HL at octave and midoctave frequencies from 125 to 8000 Hz and static acoustic admittance between 0.4 and 1.6 mmhos with peak pressure between –15 and +30 daPa (ASHA, 1990). Additionally, each subject had an ipsilateral acoustic reflex present at ≤90 dB HL in the test ear at 1 kHz, and signed an Informed Consent form (Appendix A). Summary statistics of the subject thresholds are found in Table 1.

Materials

Word lists. The preliminary Japanese corpus was drawn from 2,000 of the most frequently used words in Japan according to a corpus of 292,918 words obtained from a number of 20th century novels and stories (Kawamura, Kitamura, & Hobara, 2004), the *New International Japanese-English Dictionary* (Seya, 1994), and *Practical Japanese-English Dictionary* (Association for Overseas Technical Scholarship, 1970). Of the

Table 1

Age (in years) and Pure Tone Threshold (dB HL) Descriptive Statistics for the 20 Japanese Participants

	M	*Minimum*	*Maximum*	*SD*
Age	25.4	20	32	3.5
125 Hz	2.5	-5	15	5.7
250 Hz	1.8	-5	15	4.9
500 Hz	1.5	-5	10	4.9
750 Hz	2.3	-5	10	4.1
1000 Hz	3.3	-5	15	4.5
1500 Hz	3.5	-10	10	3.4
2000 Hz	5.0	0	15	4.3
3000 Hz	1.3	-10	10	5.2
4000 Hz	-0.8	-10	15	4.7
6000 Hz	2.3	-5	15	6.8
8000 Hz	0.8	-10	10	5.7
PTA*	3.2	-3.3	10.0	3.7

*PTA = arithmetic average of thresholds at 500, 1000, and 2000 Hz

225 trisyllabic and 396 bisyllabic words available, 69 trisyllabic and 240 bisyllabic words were selected for evaluation in this study.

Talkers. Initial recordings were made using 6 native Japanese talkers, 3 male and 3 female. All talkers were from a variety of cities located in the Tokyo, Japan area, and each spoke the standard Japanese dialect. After the initial recordings, a panel of 6 native Japanese-speaking judges as well as 1 professor of Japanese at Brigham Young University evaluated each talker's voice on evaluation forms (Appendixes B and C). The highest ranked talkers (1 male and 1 female) were selected to be the talkers for the final recordings. Neither the male nor the female were rated unacceptable in dialect or in overall acceptance by any of the judges.

Recordings. All recordings were made in a large anechoic chamber located on the Brigham Young University campus in the Eyring Science Center. A Larson-Davis model 2541 microphone was positioned approximately 15 cm from the talker at a 0° azimuth and was covered by a 7.62 cm windscreen. The microphone was connected to a Larson-Davis model 900 microphone preamp, which was coupled to a Larson-Davis model 2200 preamp power supply. The signal from the preamp power supply was routed through an Apogee AD-8000 24-bit analog-to-digital converter; the digitized signal was stored on a hard drive for later editing. A 44.1 kHz sampling rate with 24-bit quantization was used for all recordings, and every effort was made to utilize the full range of the analog-to-digital converter.

During the recording sessions, the talker was asked to pronounce each word at least 5 times. A native Japanese judge rated each word for perceived goodness of production, and the best production of each word was then selected for inclusion on the

CD. If there were no satisfactory recordings of a word, that word was re-recorded. Following the rating, the intensity of each word to be included on the CD was edited using Sadie Disk Editor software (Studio Audio & Video Ltd., 2004) to yield the same intensity as that of the 1000 Hz calibration tone contained on track 1 of the CD. The CD was produced on a PlexWriter CD-R/W using a 44.1 kHz sampling rate and 16-bit quantization. The NS high dither option in the Sadie Disk Editor software was used to convert the recordings from 24 to 16-bit quantization.

Procedures

Custom software was used to control randomization and timing of the presentation of the words. The signal was routed from a computer-controlled CD-ROM drive to the external inputs of a Grason Stadler model 1761 audiometer. The stimuli were routed from the audiometer to the subject via a single TDH-50P headphone on the test ear. The ear with the better PTA was selected as the test ear; if the PTA of both ears was within 5 dB of each other, the test ear was randomly selected. Prior to testing each subject, the inputs to the audiometer were calibrated to 0 VU using the 1 kHz calibration tone on the test CD. All testing was carried out in a double-walled sound suite that met ANSI (1999) standards for maximum permissible ambient noise levels for the ears not covered condition using one-third octave-bands.

Each subject participated in three test sessions. The first test session consisted of the pure-tone audiometric test and tympanometry as noted previously; the second and third test sessions were one and a half hours each of listening to the trisyllabic and bisyllabic stimuli for one talker. The order of presentation of the male and female talker recordings was randomly determined for each subject. During testing, each subject was given several rest periods.

Evaluation of trisyllabic words. Before the testing began the subject was read the following instructions:

> You will hear trisyllabic words, which may become louder or softer in intensity. At the very soft loudness levels it may be difficult for you to hear the words. Please repeat the word that you hear. If you are unsure of the word, you are encouraged to guess. If you have no guess, please be quiet and listen for the next word. Do you have any questions?

Each subject listened to the entire list of trisyllabic words once at 50 dB HL to become familiar with the words before the testing commenced.

The entire trisyllabic word list was presented at 13 different intensity levels, ranging from –10 to 14 dB HL in 2 dB steps, with 1.7 s silent intervals between words. Word order within the list was randomized prior to each presentation, and each list was presented beginning with the softest intensity and increasing in loudness to reduce learning effects. Each subject listened to both the male and female recordings of the trisyllabic list.

Evaluation of bisyllabic words. The subjects were not familiarized with the bisyllabic words before testing commenced. The 240 bisyllabic words were randomly divided into ten lists of 24 words each. The lists were presented at ten presentation levels ranging from -5 to 40 dB HL with 4 s silent interval between words. One list was presented at each of the ten presentation levels. The order of the presentation of the lists and the order of the words within the list were randomized for each subject. Each word was presented an equal number of times at each intensity level across the entire subject population.

Prior to the administration of the speech discrimination test, the following instructions were given:

> You will hear bisyllabic words at several different loudness levels. At the very soft loudness levels it may be difficult for you to hear the words. Please listen carefully and print legibly the words you hear in the spaces provided on the response sheets. If you are unsure of the word, you are encouraged to guess. If you have no guess, please draw a horizontal line in the space provided for that word. Do you have any questions?

Calibration. The audiometer was calibrated prior to, weekly during, and at the conclusion of data collection. Calibration was performed in accordance with the ANSI (2004) specifications. No changes in audiometric calibration were necessary during data collection.

Results

Trisyllabic Words

After the data were collected logistic regression was used to calculate the regression slope and intercept for each of the 69 trisyllabic test words. A modified logistic regression equation was used to calculate the percentage of correct recognition at each intensity level. The original logistic regression equation is:

$$\log\frac{p}{1-p} = a + b \times i \qquad (1)$$

In equation 1, p is the proportion correct at any given intensity level, a is the regression intercept, b is the regression slope, i is the intensity level in dB HL.

Equation 1 can be solved for p and multiplied by 100 to obtain the percentage of correct recognition as show in equation 2.

$$P = (1 - \frac{\exp(a + b \times i)}{1 + \exp(a + b \times i)}) * 100 \tag{2}$$

By inserting the regression slope, regression intercept, and intensity level into Equation 2, it is possible to predict percentage correct (P) recognition at any specified intensity level. Percentage of correct recognition was calculated for each trisyllabic word from -10 to 14 dB HL in 1 dB increments. A steep slope was desired because it provides less variability and is much faster at finding the patient's threshold. The psychometric functions calculated using equation 2 for the male and female talkers can be found in Figure 1, panels A and B respectively.

In order to calculate the intensity required for a given proportion, Equation 1 was solved for dB. This yields equation 3. By inserting the desired proportions into Equation 3, it is possible to calculate the threshold (the intensity required for 50% intelligibility), the slope (%/dB) at threshold, and the slope (%/dB) from 20 to 80% for each psychometric function. When solving for the threshold (p = 0.5), Equation 3 can be simplified to Equation 4.

$$i = \frac{\log \frac{p}{1 - p} - a}{b} \tag{3}$$

$$i = \frac{-a}{b} \tag{4}$$

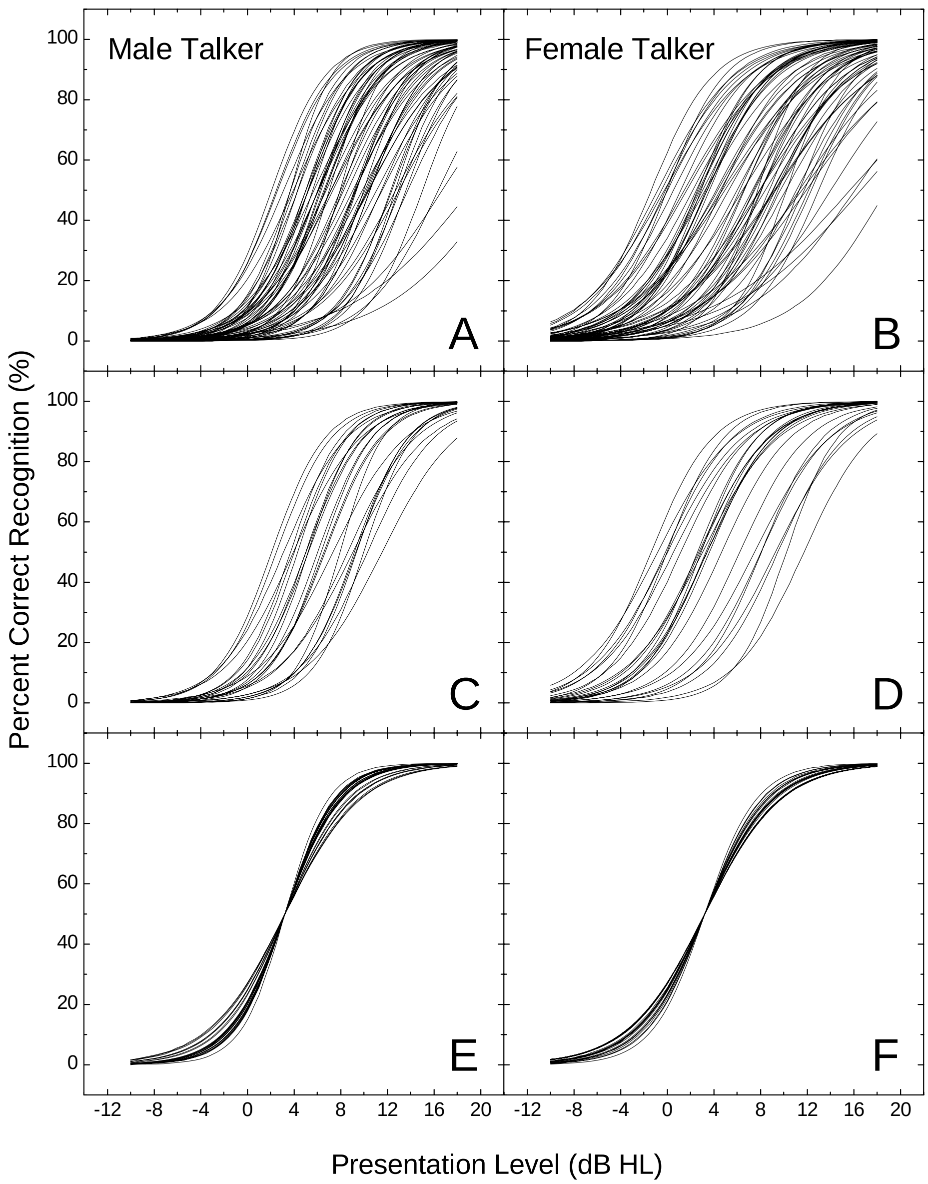

Figure 1.

Psychometric functions for Japanese trisyllabic words for male talker (left panels) and female talker (right panels) recordings. All 69 words (top panels A-B), 25 selected words (middle panels C-D), and 25 selected adjusted words (bottom panels E-F). The 25 words in the bottom panels were digitally adjusted to have 50% thresholds equal to the mean PTA (3.23 dB HL) for the 20 normally hearing subjects.

Calculations of threshold (intensity required for 50% correct perception), slope at 50%, and slope from 20% to 80% were made for each trisyllabic word using the logistic regression slopes and intercepts. Thresholds for the trisyllabic words ranged from 2.1 to 21.4 dB HL ($M = 8.7$) for the male talker and -1.4 to 18.8 dB HL ($M = 6.7$) for the female talker. The slope at 50% ranged from 4.8-14.2%/dB ($M = 9.6$) for the male talker and 4.3-12.1%/dB ($M = 7.7$) for the female talker. The slope from 20-80% ranged from 4.2-12.3%/dB ($M = 8.4$) for the male talker and 3.8-10.4%/dB ($M = 6.7$) for the female talker. When the slopes at 50% were compared with the slopes at 20-80% the slopes at 50% threshold were steeper. Slopes of the psychometric functions and 50% thresholds for all trisyllabic words are presented in Table 2 (male talker) and Table 3 (female talker).

The 25 trisyllabic words with the steepest psychometric functions for the male and female talker (slope ≥ 9.2%/dB for both male and female talkers) were chosen to be included in the final CD. The slope at 50%, slope from 20-80%, and threshold for these 25 selected words are all presented in Table 4 (male talker) and Table 5 (female talker). The psychometric functions for the final 25 selected words are contained in Figure 1, panel C (male talker) and panel D (female talker).

The final 25 selected trisyllabic words still had a wide range of variability in threshold. To improve the homogeneity with respect to audibility the intensity of each of the 25 words was digitally adjusted so that the 50% threshold of each word was equal to the mean PTA of the subjects (3.2 dB HL). The psychometric functions for each of the 25 adjusted words for the male and female talkers are depicted in Figure 1, panels E and F respectively. The psychometric functions for each of the selected 25 words are

Table 2

Mean Performance for all 69 Japanese Male Trisyllabic SRT words

Word	Kanji	Hiragana	a[a]	b[b]	Slope at 50%[c]	Slope from 20 to 80%[d]	Threshold[e]	ΔdB[f]
agaru	上る	あがる	2.48191	-0.34573	8.6	7.5	7.2	3.9
ageru	上げる	あげる	2.25454	-0.44887	11.2	9.7	5.0	1.8
anata	あなた	あなた	1.06028	-0.40687	10.2	8.8	2.6	-0.6
atama	頭	あたま	2.17182	-0.41465	10.4	9.0	5.2	2.0
hajime	初め	はじめ	2.71544	-0.41335	10.3	8.9	6.6	3.3
hanashi	話	はなし	1.88174	-0.32860	8.2	7.1	5.7	2.5
haseru	はせる	はせる	4.68111	-0.33976	8.5	7.4	13.8	10.5
hatake	畑	はたけ	1.79860	-0.44819	11.2	9.7	4.0	0.8
hidari	左	ひだり	2.27700	-0.33630	8.4	7.3	6.8	3.5
higashi	東	ひがし	2.91393	-0.36426	9.1	7.9	8.0	4.8
himitsu	秘密	ひみつ	4.42807	-0.42054	10.5	9.1	10.5	7.3
hiraku	開く	ひらく	1.35666	-0.34377	8.6	7.4	3.9	0.7
ichiban	一番	いちばん	2.59808	-0.42970	10.7	9.3	6.0	2.8
ichido	一度	いちど	5.11885	-0.41286	10.3	8.9	12.4	9.2
idaku	抱く	いだく	4.01318	-0.23996	6.0	5.2	16.7	13.5
ikeru	いける	いける	4.47676	-0.20901	5.2	4.5	21.4	18.2
ikiru	生きる	いきる	2.82433	-0.31195	7.8	6.8	9.1	5.8
jigoku	地獄	じごく	4.20307	-0.44877	11.2	9.7	9.4	6.1
jisatsu	自殺	じさつ	6.03504	-0.47558	11.9	10.3	12.7	9.5
kagami	鏡	かがみ	5.02475	-0.38292	9.6	8.3	13.1	9.9
kagiru	限る	かぎる	3.31551	-0.29890	7.5	6.5	11.1	7.9
kakeru	かける	かける	2.35942	-0.38845	9.7	8.4	6.1	2.8
kareru	かれる	かれる	2.10962	-0.34454	8.6	7.5	6.1	2.9
kashira	かしら	かしら	2.84467	-0.34421	8.6	7.4	8.3	5.0
katachi	形	かたち	1.75555	-0.40576	10.1	8.8	4.3	1.1
kataru	語る	かたる	2.79905	-0.41979	10.5	9.1	6.7	3.4
kieru	消える	きえる	3.54741	-0.30687	7.7	6.6	11.6	8.3
kochira	こちら	こちら	3.45721	-0.42587	10.6	9.2	8.1	4.9
kodomo	子供	こども	1.14090	-0.36577	9.1	7.9	3.1	-0.1
kotae	答	こたえ	2.34334	-0.31884	8.0	6.9	7.3	4.1
kudaru	下る	くだる	3.77356	-0.36927	9.2	8.0	10.2	7.0
kumoru	曇る	くもる	2.72900	-0.40876	10.2	8.8	6.7	3.4
kuruma	車	くるま	2.93336	-0.34087	8.5	7.4	8.6	5.4
mattaku	全く	まったく	0.90938	-0.43289	10.8	9.4	2.1	-1.1
migite	右手	みぎて	3.69430	-0.19288	4.8	4.2	19.2	15.9
miseru	見せる	みせる	6.37632	-0.42417	10.6	9.2	15.0	11.8
momoko	桃子	ももこ	1.96608	-0.37364	9.3	8.1	5.3	2.0
musume	娘	むすめ	4.42807	-0.42054	10.5	9.1	10.5	7.3
nageru	投げる	なげる	2.26005	-0.37109	9.3	8.0	6.1	2.9
namae	名前	なまえ	2.02023	-0.46850	11.7	10.1	4.3	1.1
narabu	並ぶ	ならぶ	2.04014	-0.40490	10.1	8.8	5.0	1.8

Word	Kanji	Hiragana	a[a]	b[b]	Slope at 50%[c]	Slope from 20 to 80%[d]	Threshold[e]	ΔdB[f]
nasuru	なする	なする	5.80575	-0.42629	10.7	9.2	13.6	10.4
nemuru	眠る	ねむる	3.57817	-0.34720	8.7	7.5	10.3	7.1
noboru	のぼる	のぼる	2.88834	-0.29251	7.3	6.3	9.9	6.6
okiru	起きる	おきる	2.48375	-0.47597	11.9	10.3	5.2	2.0
onaji	同じ	おなじ	3.57434	-0.50827	12.7	11.0	7.0	3.8
otoko	男	おとこ	2.74430	-0.48835	12.2	10.6	5.6	2.4
oyobu	及ぶ	およぶ	4.12168	-0.35893	9.0	7.8	11.5	8.2
sagasu	探す	さがす	3.14378	-0.30128	7.5	6.5	10.4	7.2
sageru	下げる	さげる	3.68275	-0.28932	7.2	6.3	12.7	9.5
semaru	迫る	せまる	5.67628	-0.43754	10.9	9.5	13.0	9.7
shidaini	次第に	しだいに	3.41834	-0.36716	9.2	7.9	9.3	6.1
shigoto	仕事	しごと	1.71649	-0.46281	11.6	10.0	3.7	0.5
shimeru	しめる	しめる	4.26897	-0.53770	13.4	11.6	7.9	4.7
soreni	それに	それに	4.66860	-0.46731	11.7	10.1	10.0	6.8
subete	すべて	すべて	3.46526	-0.34366	8.6	7.4	10.1	6.9
suwaru	座る	すわる	3.21547	-0.34728	8.7	7.5	9.3	6.0
taberu	食べる	たべる	2.91927	-0.46836	11.7	10.1	6.2	3.0
tateru	立てる	たてる	5.33895	-0.32593	8.1	7.1	16.4	13.1
tomeru	留める	とめる	3.93308	-0.42844	10.7	9.3	9.2	5.9
ugoku	動く	うごく	2.20931	-0.30852	7.7	6.7	7.2	3.9
ukabu	浮ぶ	うかぶ	5.36509	-0.43606	10.9	9.4	12.3	9.1
ukeru	受ける	うける	3.79460	-0.29169	7.3	6.3	13.0	9.8
wakaru	わかる	わかる	1.05218	-0.42017	10.5	9.1	2.5	-0.7
wataru	渡る	わたる	2.19831	-0.41989	10.5	9.1	5.2	2.0
watashi	私	わたし	2.09607	-0.56614	14.2	12.3	3.7	0.5
watasu	渡す	わたす	3.03937	-0.29322	7.3	6.3	10.4	7.1
yameru	やめる	やめる	2.88265	-0.45466	11.4	9.8	6.3	3.1
yaseru	痩せる	やせる	3.87432	-0.41618	10.4	9.0	9.3	6.1
		M	3.19237	-0.38593	9.6	8.4	8.7	5.4
		Minimum	0.90938	-0.56614	4.8	4.2	2.1	-1.1
		Maximum	6.37632	-0.19288	14.2	12.3	21.4	18.2
		Range	5.46694	0.37326	9.3	8.1	19.3	19.3
		SD	1.26906	0.07240	1.8	1.6	4.0	4.0

[a]*a* = regression intercept. [b]*b* = regression slope. [c]Psychometric function slope (%/dB) at 50% was calculated from 49.999 to 50.001%. [d]Psychometric function slope (%/dB) from 20-80%. [e]Intensity required for 50% intelligibility. [f]Change in intensity required to adjust the threshold of a word to the mean PTA of the subjects (3.23 dB HL)

Table 3

Mean Performance for all 69 Japanese Female Trisyllabic SRT words

Word	Kanji	Hiragana	a[a]	b[b]	Slope at 50%[c]	Slope from 20 to 80%[d]	Threshold[e]	ΔdB[f]
agaru	上る	あがる	1.21765	-0.28957	7.2	6.3	4.2	1.0
ageru	上げる	あげる	0.17026	-0.31031	7.8	6.7	0.5	-2.7
anata	あなた	あなた	-0.06203	-0.27657	6.9	6.0	-0.2	-3.5
atama	頭	あたま	-0.24863	-0.30458	7.6	6.6	-0.8	-4.0
hajime	初め	はじめ	1.32921	-0.36632	9.2	7.9	3.6	0.4
hanashi	話	はなし	3.31551	-0.29890	7.5	6.5	11.1	7.9
haseru	はせる	はせる	2.69944	-0.23806	6.0	5.2	11.3	8.1
hatake	畑	はたけ	0.00852	-0.30943	7.7	6.7	0.0	-3.2
hidari	左	ひだり	1.15605	-0.24434	6.1	5.3	4.7	1.5
higashi	東	ひがし	2.47266	-0.33320	8.3	7.2	7.4	4.2
himitsu	秘密	ひみつ	2.20485	-0.33619	8.4	7.3	6.6	3.3
hiraku	開く	ひらく	1.24091	-0.37369	9.3	8.1	3.3	0.1
ichiban	一番	いちばん	0.95359	-0.33817	8.5	7.3	2.8	-0.4
ichido	一度	いちど	2.62206	-0.28973	7.2	6.3	9.1	5.8
idaku	抱く	いだく	2.72192	-0.17358	4.3	3.8	15.7	12.5
ikeru	いける	いける	2.90598	-0.28576	7.1	6.2	10.2	6.9
ikiru	生きる	いきる	1.57940	-0.33800	8.4	7.3	4.7	1.4
jigoku	地獄	じごく	2.88884	-0.31091	7.8	6.7	9.3	6.1
jisatsu	自殺	じさつ	4.29343	-0.34759	8.7	7.5	12.4	9.1
kagami	鏡	かがみ	3.20827	-0.36637	9.2	7.9	8.8	5.5
kagiru	限る	かぎる	2.74598	-0.30164	7.5	6.5	9.1	5.9
kakeru	かける	かける	2.19964	-0.27636	6.9	6.0	8.0	4.7
kareru	かれる	かれる	1.92285	-0.24218	6.1	5.2	7.9	4.7
kashira	かしら	かしら	3.46267	-0.24661	6.2	5.3	14.0	10.8
katachi	形	かたち	1.19663	-0.24107	6.0	5.2	5.0	1.7
kataru	語る	かたる	3.56036	-0.22128	5.5	4.8	16.1	12.9
kieru	消える	きえる	3.97201	-0.33856	8.5	7.3	11.7	8.5
kochira	こちら	こちら	2.12499	-0.22831	5.7	4.9	9.3	6.1
kodomo	子供	こども	-0.05235	-0.34323	8.6	7.4	-0.2	-3.4
kotae	答	こたえ	1.01478	-0.38917	9.7	8.4	2.6	-0.6
kudaru	下る	くだる	2.07865	-0.22573	5.6	4.9	9.2	6.0
kumoru	曇る	くもる	3.26294	-0.34342	8.6	7.4	9.5	6.3
kuruma	車	くるま	0.39528	-0.33517	8.4	7.3	1.2	-2.1
mattaku	全く	まったく	-0.51219	-0.37574	9.4	8.1	-1.4	-4.6
migite	右手	みぎて	2.42291	-0.36615	9.2	7.9	6.6	3.4
miseru	見せる	みせる	4.91367	-0.26179	6.5	5.7	18.8	15.5
momoko	桃子	ももこ	-0.15247	-0.30369	7.6	6.6	-0.5	-3.7
musume	娘	むすめ	2.40730	-0.20828	5.2	4.5	11.6	8.3
nageru	投げる	なげる	1.18131	-0.27228	6.8	5.9	4.3	1.1
namae	名前	なまえ	-0.00909	-0.40541	10.1	8.8	0.0	-3.3
narabu	並ぶ	ならぶ	0.92684	-0.30501	7.6	6.6	3.0	-0.2

Word	Kanji	Hiragana	a[a]	b[b]	Slope at 50%[c]	Slope from 20 to 80%[d]	Threshold[e]	ΔdB[f]
nasuru	なする	なする	4.13964	-0.34166	8.5	7.4	12.1	8.9
nemuru	眠る	ねむる	3.04494	-0.37670	9.4	8.2	8.1	4.9
noboru	のぼる	のぼる	0.90832	-0.27804	7.0	6.0	3.3	0.0
okiru	起きる	おきる	1.20387	-0.35097	8.8	7.6	3.4	0.2
onaji	同じ	おなじ	1.64290	-0.25352	6.3	5.5	6.5	3.3
otoko	男	おとこ	0.40460	-0.27497	6.9	6.0	1.5	-1.8
oyobu	及ぶ	およぶ	2.18006	-0.25913	6.5	5.6	8.4	5.2
sagasu	探す	さがす	2.19964	-0.27636	6.9	6.0	8.0	4.7
sageru	下げる	さげる	2.95509	-0.17790	4.4	3.8	16.6	13.4
semaru	迫る	せまる	4.65996	-0.35869	9.0	7.8	13.0	9.8
shidaini	次第に	しだいに	2.17331	-0.29746	7.4	6.4	7.3	4.1
shigoto	仕事	しごと	1.19825	-0.41198	10.3	8.9	2.9	-0.3
shimeru	しめる	しめる	4.62366	-0.45168	11.3	9.8	10.2	7.0
soreni	それに	それに	2.73407	-0.33929	8.5	7.3	8.1	4.8
subete	すべて	すべて	0.82869	-0.32966	8.2	7.1	2.5	-0.7
suwaru	座る	すわる	1.47463	-0.27866	7.0	6.0	5.3	2.1
taberu	食べる	たべる	0.45814	-0.27233	6.8	5.9	1.7	-1.5
tateru	立てる	たてる	2.62432	-0.21984	5.5	4.8	11.9	8.7
tomeru	留める	とめる	2.30217	-0.30719	7.7	6.6	7.5	4.3
ugoku	動く	うごく	1.26410	-0.27835	7.0	6.0	4.5	1.3
ukabu	浮ぶ	うかぶ	3.74511	-0.48265	12.1	10.4	7.8	4.5
ukeru	受ける	うける	4.47767	-0.39558	9.9	8.6	11.3	8.1
wakaru	わかる	わかる	1.16198	-0.33822	8.5	7.3	3.4	0.2
wataru	渡る	わたる	1.76251	-0.29326	7.3	6.3	6.0	2.8
watashi	私	わたし	0.65219	-0.29529	7.4	6.4	2.2	-1.0
watasu	渡す	わたす	2.88049	-0.29605	7.4	6.4	9.7	6.5
yameru	やめる	やめる	0.89304	-0.32836	8.2	7.1	2.7	-0.5
yaseru	痩せる	やせる	2.12272	-0.34050	8.5	7.4	6.2	3.0
		M	1.97763	-0.30821	7.7	6.7	6.7	3.5
		Minimum	-0.51219	-0.48265	4.3	3.8	-1.4	-4.6
		Maximum	4.91367	-0.17358	12.1	10.4	18.8	15.5
		Range	5.42586	0.30907	7.7	6.7	20.1	20.1
		SD	1.33836	0.05959	1.5	1.3	4.7	4.7

[a]*a* = regression intercept. [b]*b* = regression slope. [c]Psychometric function slope (%/dB) at 50% was calculated from 49.999 to 50.001%. [d]Psychometric function slope (%/dB) from 20-80%. [e]Intensity required for 50% intelligibility. [f]Change in intensity required to adjust the threshold of a word to the mean PTA of the subjects (3.23 dB HL)

Table 4

Mean Performance for 25 Selected Japanese Male Trisyllabic SRT Words

Word	Kanji	Hiragana	a[a]	b[b]	Slope at 50%[c]	Slope from 20 to 80%[d]	Threshold[e]	ΔdB[f]
ageru	上げる	あげる	2.25454	-0.44887	11.2	9.7	5.0	1.8
atama	頭	あたま	2.17182	-0.41465	10.4	9.0	5.2	2.0
hajime	初め	はじめ	2.71544	-0.41335	10.3	8.9	6.6	3.3
hatake	畑	はたけ	1.79860	-0.44819	11.2	9.7	4.0	0.8
hiraku	開く	ひらく	1.35666	-0.34377	8.6	7.4	3.9	0.7
ichiban	一番	いちばん	2.59808	-0.42970	10.7	9.3	6.0	2.8
ikiru	生きる	いきる	2.82433	-0.31195	7.8	6.8	9.1	5.8
jigoku	地獄	じごく	4.20307	-0.44877	11.2	9.7	9.4	6.1
kieru	消える	きえる	3.54741	-0.30687	7.7	6.6	11.6	8.3
kodomo	子供	こども	1.14090	-0.36577	9.1	7.9	3.1	-0.1
kotae	答	こたえ	2.34334	-0.31884	8.0	6.9	7.3	4.1
kumoru	曇る	くもる	2.72900	-0.40876	10.2	8.8	6.7	3.4
kuruma	車	くるま	2.93336	-0.34087	8.5	7.4	8.6	5.4
mattaku	全く	まったく	0.90938	-0.43289	10.8	9.4	2.1	-1.1
namae	名前	なまえ	2.02023	-0.46850	11.7	10.1	4.3	1.1
narabu	並ぶ	ならぶ	2.04014	-0.40490	10.1	8.8	5.0	1.8
nemuru	眠る	ねむる	3.57817	-0.34720	8.7	7.5	10.3	7.1
okiru	起きる	おきる	2.48375	-0.47597	11.9	10.3	5.2	2.0
shigoto	仕事	しごと	1.71649	-0.46281	11.6	10.0	3.7	0.5
shimeru	しめる	しめる	4.26897	-0.53770	13.4	11.6	7.9	4.7
soreni	それに	それに	4.66860	-0.46731	11.7	10.1	10.0	6.8
tomeru	留める	とめる	3.93308	-0.42844	10.7	9.3	9.2	6.0
wakaru	わかる	わかる	1.05218	-0.42017	10.5	9.1	2.5	-0.7
yameru	やめる	やめる	2.88265	-0.45466	11.4	9.8	6.3	3.1
yaseru	痩せる	やせる	3.87432	-0.41618	10.4	9.0	9.3	6.1
		M	2.64178	-0.41268	10.3	8.9	6.5	3.3
		Minimum	0.90938	-0.53770	7.7	6.6	2.1	-1.1
		Maximum	4.66860	-0.30687	13.4	11.6	11.6	8.3
		Range	3.75922	0.23083	5.8	5.0	9.5	9.5
		SD	1.05081	0.05828	1.5	1.3	2.7	2.7

[a]*a* = regression intercept. [b]*b* = regression slope. [c]Psychometric function slope (%/dB) at 50% was calculated from 49.999 to 50.001%. [d]Psychometric function slope (%/dB) from 20-80%. [e]Intensity required for 50% intelligibility. [f]Change in intensity required to adjust the threshold of a word to the mean PTA of the subjects (3.23 dB HL)

Table 5

Mean Performance for 25 Selected Japanese Female Trisyllabic SRT Words

Word	Kanji	Hiragana	a[a]	b[b]	Slope at 50%[c]	Slope from 20 to 80%[d]	Threshold[e]	ΔdB[f]
ageru	上げる	あげる	0.17026	-0.31031	7.8	6.7	0.5	-2.7
atama	頭	あたま	-0.24863	-0.30458	7.6	6.6	-0.8	-4.0
hajime	初め	はじめ	1.32921	-0.36632	9.2	7.9	3.6	0.4
hatake	畑	はたけ	0.00852	-0.30943	7.7	6.7	0.0	-3.2
hiraku	開く	ひらく	1.24091	-0.37369	9.3	8.1	3.3	0.1
ichiban	一番	いちばん	0.95359	-0.33817	8.5	7.3	2.8	-0.4
ikiru	生きる	いきる	1.57940	-0.33800	8.4	7.3	4.7	1.4
jigoku	地獄	じごく	2.88884	-0.31091	7.8	6.7	9.3	6.1
kieru	消える	きえる	3.97201	-0.33856	8.5	7.3	11.7	8.5
kodomo	子供	こども	-0.05235	-0.34323	8.6	7.4	-0.2	-3.4
kotae	答	こたえ	1.01478	-0.38917	9.7	8.4	2.6	-0.6
kumoru	曇る	くもる	3.26294	-0.34342	8.6	7.4	9.5	6.3
kuruma	車	くるま	0.39528	-0.33517	8.4	7.3	1.2	-2.1
mattaku	全く	まったく	-0.51219	-0.37574	9.4	8.1	-1.4	-4.6
namae	名前	なまえ	-0.00909	-0.40541	10.1	8.8	0.0	-3.3
narabu	並ぶ	ならぶ	0.92684	-0.30501	7.6	6.6	3.0	-0.2
nemuru	眠る	ねむる	3.04494	-0.37670	9.4	8.2	8.1	4.9
okiru	起きる	おきる	1.20387	-0.35097	8.8	7.6	3.4	0.2
shigoto	仕事	しごと	1.19825	-0.41198	10.3	8.9	2.9	-0.3
shimeru	しめる	しめる	4.62366	-0.45168	11.3	9.8	10.2	7.0
soreni	それに	それに	2.73407	-0.33929	8.5	7.3	8.1	4.8
tomeru	留める	とめる	2.30217	-0.30719	7.7	6.6	7.5	4.3
wakaru	わかる	わかる	1.16198	-0.33822	8.5	7.3	3.4	0.2
yameru	やめる	やめる	0.89304	-0.32836	8.2	7.1	2.7	-0.5
yaseru	痩せる	やせる	2.12272	-0.34050	8.5	7.4	6.2	3.0
		M	1.44820	-0.34928	8.7	7.6	4.1	0.9
		Minimum	-0.51219	-0.45168	7.6	6.6	-1.4	-4.6
		Maximum	4.62366	-0.30458	11.3	9.8	11.7	8.5
		Range	5.13585	0.14710	3.7	3.2	13.1	13.1
		SD	1.36033	0.03718	0.9	0.8	3.7	3.7

[a]*a* = regression intercept. [b]*b* = regression slope. [c]Psychometric function slope (%/dB) at 50% was calculated from 49.999 to 50.001%. [d]Psychometric function slope (%/dB) from 20-80%. [e]Intensity required for 50% intelligibility. [f]Change in intensity required to adjust the threshold of a word to the mean PTA of the subjects (3.23 dB HL)

included in Figure 2. The raw data for the male talker are represented by the filled triangles and the raw data for the female talker is symbolized by the open circles. Figure 2 presents the calculated psychometric functions compared to the raw data. The data comparison, before and after adjustment, for the male talker and the female talker can be found in Figure 3.

Bisyllabic Words

After the raw data were collected logistic regression was used to obtain regression slopes for each of the 240 bisyllabic words. The 240 words were then ranked from steep to shallow slopes. The 200 words with the steepest slopes were divided into 4 lists of 50 words each. Each list was counterbalanced using random block assignment. The first 4 words from the rank-ordered list of 200 were randomly assigned to one of 4 lists. This process was repeated until each list consisted of 50 words. Table 6 (male talker) and Table 7 (female talker) contain the four balanced lists of bisyllabic words.

Once the 4 full-lists were created 8 half-lists of 25 words each were constructed after the creation of the 4 balanced 50-word lists. The half-lists were developed from each full list by designating the first word in the list as an A or a B, designating the second word with the opposite letter, and then counterbalancing the assignment of the remaining words. Once all the words were assigned a letter the full-list could be divided into 2 half-lists. Half-lists are included in Table 8 for the male talker and Table 9 for the female talker. Once again the lists are shown in Romanization, Kanji, and Hiragana going from left to right.

Once the bisyllabic lists and half-lists were created, logistic regression was used to calculate regression slopes intercepts for each of the lists and half-lists for both the

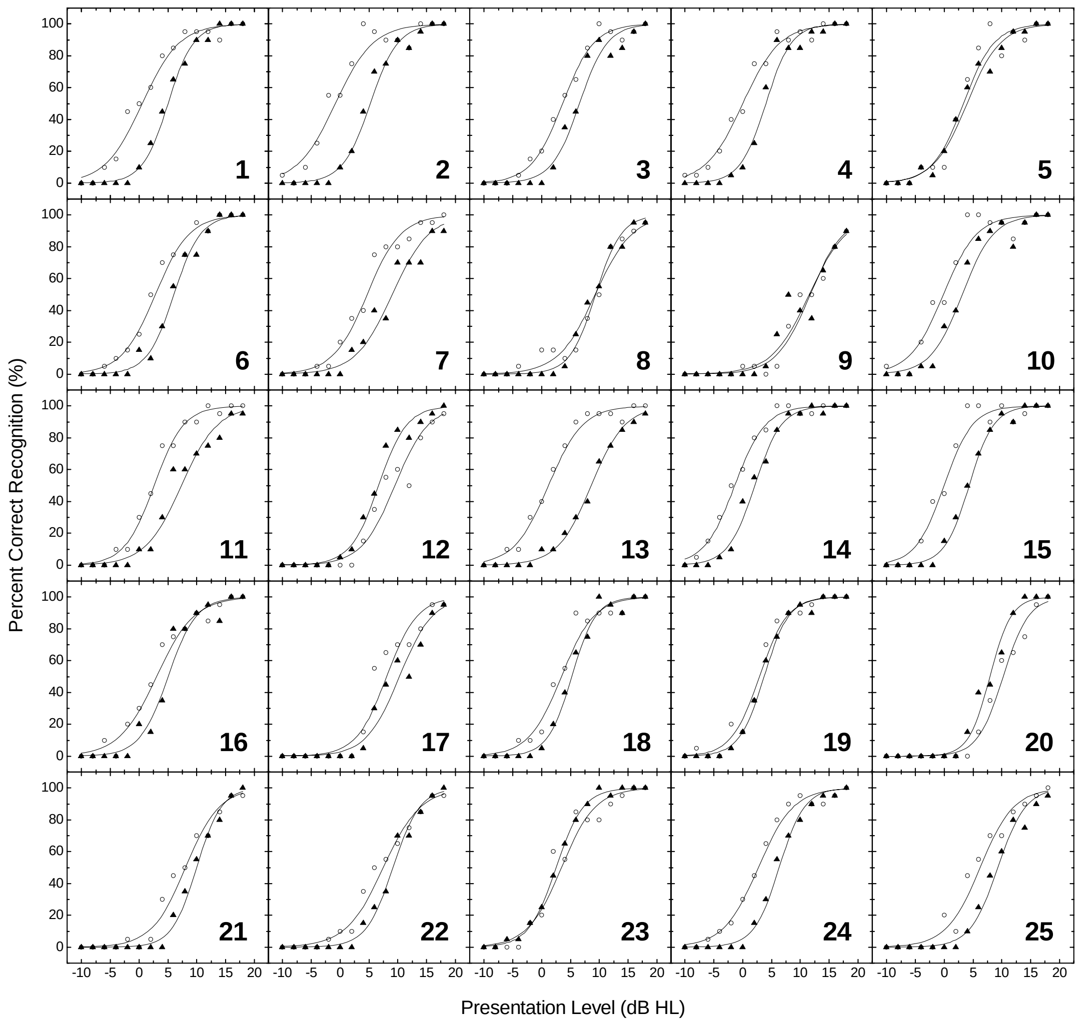

Figure 2.

Psychometric functions for the 25 selected Japanese trisyllabic words spoken by male (filled triangles) and female (open circles). The functions were calculated using logistic regression; the symbols represent mean percentage of correct recognition calculated from the raw data for 20 normally hearing subjects.

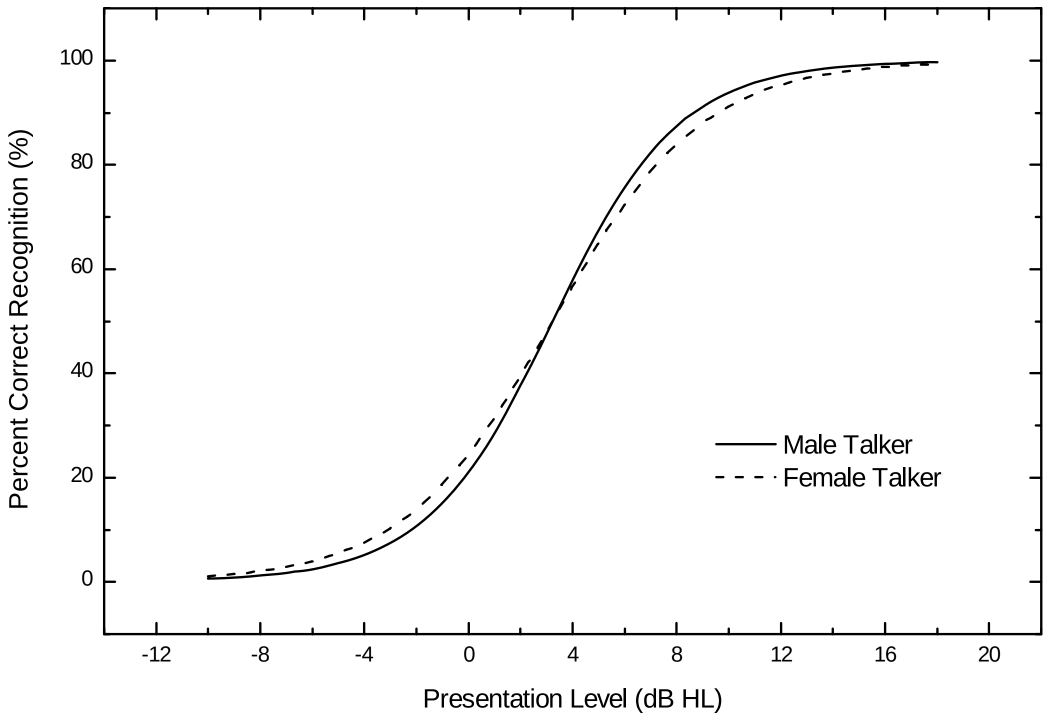

Figure 3.

Mean psychometric functions for 25 selected Japanese male and female talker trisyllabic words after intensity adjustment to equate 50% threshold performance to the mean PTA (3.23 dB HL) for the 20 normally hearing subjects.

Table 6

Japanese Male Talker Bisyllabic Lists (50 Words) in Rank Order from Difficult to Easy

Full-lists - Romanization				Full-lists - Kanji				Full-lists - Hiragana			
1	2	3	4	1	2	3	4	1	2	3	4
utsu	daijin	jiyuu	sumi	打つ	大臣	自由	隅	うつ	だいじん	じゆう	すみ
kimi	kiku	kappa	nanto	君	聞く	河童	何と	きみ	きく	かっぱ	なんと
ippou	kakkou	ito	koori	一方	恰好	糸	氷	いっぽう	かっこう	いと	こおり
neesan	tooru	doumo	donna	姉さん	通る	どうも	どんな	ねえさん	とおる	どうも	どんな
mazu	chiru	zengo	tsuma	先ず	散る	前後	妻	まず	ちる	ぜんご	つま
sake	sara	mimi	koukei	酒	皿	耳	光景	さけ	さら	みみ	こうけい
jiki	shinu	shouji	soto	磁器	死ぬ	障子	外	じき	しぬ	しょうじ	そと
nazo	jikka	hebi	ase	謎	実家	蛇	汗	なぞ	じっか	へび	あせ
kyoumi	iwa	baka	gogo	興味	岩	馬鹿	午後	きょうみ	いわ	ばか	ごご
hosu	saka	issai	haru	干す	坂	一切	張る	ほす	さか	いっさい	はる
kata	seki	osu	toru	型	席	押す	取る	かた	せき	おす	とる
haji	jishin	ittai	hifu	恥	自身	一体	皮膚	はじ	じしん	いったい	ひふ
nanji	yuki	roujin	waza	何時	雪	老人	業	なんじ	ゆき	ろうじん	わざ
itsu	shima	niisan	uta	何時	島	兄さん	歌	いつ	しま	にいさん	うた
hone	kyoufu	naze	sanjyuu	骨	恐怖	何故	三十	ほね	きょうふ	なぜ	さんじゆう
futo	imi	kesshin	saku	ふと	意味	決心	咲く	ふと	いみ	けっしん	さく
eru	enryo	keru	kesu	得る	遠慮	蹴る	消す	える	えんりょ	ける	けす
ana	kumo	wake	jitto	穴	雲	訳	じっと	あな	くも	わけ	じっと
sobo	ie	tama	koro	祖母	家	玉	頃	そぼ	いえ	たま	ころ
ame	neko	tada	aki	雨	猫	只	秋	あめ	ねこ	ただ	あき
yobu	taitei	kitto	genkou	呼ぶ	大抵	きっと	原稿	よぶ	たいてい	きっと	げんこう
saki	shiku	taka	hanbun	先	敷く	鷹	半分	さき	しく	たか	はんぶん
natsu	naku	datte	haigo	夏	泣く	だって	背後	なつ	なく	だって	はいご
gunjin	oba	tooi	shumi	軍人	伯母	遠い	趣味	ぐんじん	おば	とおい	しゅみ
yoshi	nesshin	shigai	mondai	善し	熱心	死骸	問題	よし	ねっしん	しがい	もんだい

Full-lists - Romanization				Full-lists - Kanji				Full-lists - Hiragana			
1	2	3	4	1	2	3	4	1	2	3	4
uma	koko	geki	mizu	馬	ここ	劇	水	うま	ここ	げき	みず
tantei	hachi	toori	choushi	探偵	八	通り	調子	たんてい	はち	とおり	ちょうし
aka	sugu	sonzai	take	赤	直ぐ	存在	竹	あか	すぐ	そんざい	たけ
deha	shiru	ushi	motto	では	知る	牛	もっと	では	しる	うし	もっと
heya	machi	toshi	oya	部屋	町	年	親	へや	まち	とし	おや
katsu	mato	saigo	kuchi	勝つ	的	最後	口	かつ	まと	さいご	くち
shiro	aku	karu	hara	白	悪	刈る	腹	しろ	あく	かる	はら
tani	shintai	fune	shika	谷	身体	舟	鹿	たに	しんたい	ふね	しか
yome	taido	koe	yaku	嫁	態度	声	役	よめ	たいど	こえ	やく
shiri	nana	waku	ningen	尻	七	湧く	人間	しり	しち	わく	にんげん
oku	ikken	konna	mahi	置く	一軒	こんな	麻痺	おく	いっけん	こんな	まひ
kome	chisai	ido	gojuu	米	小さい	井戸	五十	こめ	ちいさい	いど	ごじゅう
jimu	ari	hana	doko	事務	蟻	花	何処	じむ	あり	はな	どこ
densha	yonjuu	dame	nyoubou	電車	四十	駄目	女房	でんしゃ	よんじゅう	だめ	にょうぼう
jiko	demo	dare	haba	自己	でも	誰	幅	じこ	でも	だれ	はば
kagen	keiken	otto	yado	加減	経験	夫	宿	かげん	けいけん	おっと	やど
haha	kesa	kaki	shoku	母	今朝	垣	食	はは	けさ	かき	しょく
shinshi	kaku	sensei	kane	紳士	書く	先生	金	しんし	かく	せんせい	かね
yoku	ashi	kondo	geisha	よく	足	今度	芸者	よく	あし	こんど	げいしゃ
yama	yami	yoru	haku	山	闇	夜	吐く	やま	やみ	よる	はく
aite	kage	negau	yaru	相手	影	願う	遣る	あいて	かげ	ねがう	やる
sora	gake	yatto	ikka	空	崖	やっと	一家	そら	がけ	やっと	いっか
kekkou	kado	kago	jama	結構	角	籠	邪魔	けっこう	かど	かご	じゃま
mago	kenka	haka	kasa	孫	喧嘩	墓	傘	まご	けんか	はか	かさ
denwa	kawa	kekka	kabe	電話	皮	結果	壁	でんわ	かわ	けっか	かべ

Table 7

Japanese Female Talker Bisyllabic Lists (50 Words) in Rank Order from Difficult to Easy

Full-lists - Romanization				Full-lists - Kanji				Full-lists - Hiragana			
1	2	3	4	1	2	3	4	1	2	3	4
kyoufu	jikka	sumi	koko	恐怖	実家	隅	ここ	きょうふ	じっか	すみ	ここ
mina	geisha	shima	kitto	皆	芸者	島	きっと	みな	げいしゃ	しま	きっと
kane	tane	shika	ie	金	種	鹿	家	かね	たね	しか	いえ
sugu	shiro	rouba	zengo	直ぐ	白	老婆	前後	すぐ	しろ	ろうば	ぜんご
sanpo	haka	enryo	tatsu	散歩	墓	遠慮	立つ	さんぽ	はか	えんりょ	たつ
konna	tsuma	niisan	naku	こんな	妻	兄さん	泣く	こんな	つま	にいさん	なく
mago	toori	ito	chiru	孫	通り	糸	散る	まご	とおり	いと	ちる
kyoumi	kuchi	toku	sono	興味	口	得	其の	きょうみ	くち	とく	その
jimu	jiyuu	nanto	shinu	事務	自由	何と	死ぬ	じむ	じゆう	なんと	しぬ
dake	fumu	ushi	michi	丈	踏む	牛	道	だけ	ふむ	うし	みち
roujin	niku	kiku	itsu	老人	肉	聞く	何時	ろうじん	にく	きく	いつ
gogo	ippou	iwa	waku	午後	一方	岩	湧く	ごご	いっぽう	いわ	わく
genkou	haba	saku	kusa	原稿	幅	咲く	草	げんこう	はば	さく	くさ
kakkou	nanji	osu	kekka	恰好	何時	押す	結果	かっこう	なんじ	おす	けっか
dame	daijin	raku	toshi	駄目	大臣	楽	年	だめ	だいじん	らく	とし
uma	sonzai	yoshi	shinshi	馬	存在	善し	紳士	うま	そんざい	よし	しんし
tani	shiri	gunjin	tama	谷	尻	軍人	玉	たに	しり	ぐんじん	たま
keiken	kenka	eru	mazu	経験	喧嘩	得る	先ず	けいけん	けんか	える	まず
hifu	hachi	taitei	doumo	皮膚	八	大抵	どうも	ひふ	はち	たいてい	どうも
karu	oku	tantei	uta	刈る	置く	探偵	歌	かる	おく	たんてい	うた
waza	hana	kagen	koro	業	花	加減	頃	わざ	はな	かげん	ころ
mato	katsu	fune	hara	的	勝つ	舟	腹	まと	かつ	ふね	はら
yami	utsu	nami	yatto	闇	打つ	波	やっと	やみ	うつ	なみ	やっと
deha	yado	aite	ari	では	宿	相手	蟻	では	やど	あいて	あり
yobu	kaku	ningen	negau	呼ぶ	書く	人間	願う	よぶ	かく	にんげん	ねがう

Full-lists - Romanization				Full-lists - Kanji				Full-lists - Hiragana			
1	2	3	4	1	2	3	4	1	2	3	4
take	jishin	neesan	mimi	竹	自身	姉さん	耳	たけ	じしん	ねえさん	みみ
nazo	ikka	hosu	mayu	謎	一家	干す	眉	なぞ	いっか	ほす	まゆ
natsu	heya	hairu	hebi	夏	部屋	入る	蛇	なつ	へや	はいる	へび
toru	shoku	chisai	shumi	取る	食	**小さい**	趣味	とる	しょく	ちいさい	しゅみ
otto	kesshin	yuki	shouji	夫	決心	雪	障子	おっと	けっしん	ゆき	しょうじ
mizu	chyoushi	nesshin	saru	水	調子	熱心	去る	みず	ちょうし	ねっしん	さる
migi	haha	hanbun	haku	右	母	半分	吐く	みぎ	はは	はんぶん	はく
kekkou	saigo	naze	densha	結構	最後	何故	電車	けっこう	さいご	なぜ	でんしゃ
tooi	ikken	ana	kage	遠い	一軒	穴	影	とおい	いっけん	あな	かげ
sayou	taido	kabe	kappa	作用	態度	壁	河童	さよう	たいど	かべ	かっぱ
dono	ido	doko	hone	どの	井戸	何処	骨	どの	いど	どこ	ほね
yonjuu	aki	tooru	sanjyuu	四十	秋	通る	三十	よんじゅう	あき	とおる	さんじゆう
oya	kumo	horu	nyoubou	親	雲	掘る	女房	おや	くも	ほる	にょうぼう
kesa	kaki	gake	mahi	今朝	垣	崖	麻痺	けさ	かき	がけ	まひ
haji	issai	byounin	kome	恥	一切	病人	米	はじ	いっさい	びょうにん	こめ
denwa	aku	baka	demo	電話	悪	馬鹿	でも	でんわ	あく	ばか	でも
aka	motto	koe	sensei	赤	もっと	声	先生	あか	もっと	こえ	せんせい
koori	yome	datte	tada	氷	嫁	だって	只	こおり	よめ	だって	ただ
oba	nana	kago	donna	伯母	七	籠	どんな	おば	しち	かご	どんな
jama	gojuu	ashi	mondai	邪魔	五十	足	問題	じゃま	ごじゅう	あし	もんだい
yaru	douse	yoku	machi	遣る	どうせ	よく	町	やる	どうせ	よく	まち
sora	kasa	yama	kondo	空	傘	山	今度	そら	かさ	やま	こんど
yoru	kawa	kado	yaku	夜	皮	角	役	よる	かわ	かど	やく
soto	ame	sobo	wake	外	雨	祖母	訳	そと	あめ	そぼ	わけ
nando	neko	dare	ase	何度	猫	誰	汗	なんど	ねこ	だれ	あせ

Table 8

Japanese Male Talker Bisyllabic Half-lists (25 Words) in Rank Order from Difficult to Easy

Half-lists - Romanization				Half-lists - Kanji				Half-lists - Hiragana			
1A	2A	3A	4A	1A	2A	3A	4A	1A	2A	3A	4A
kimi	kawa	ito	kabe	君	皮	糸	壁	きみ	かわ	いと	かべ
ippou	kiku	doumo	sumi	一方	聞く	どうも	隅	いっぽう	きく	どうも	すみ
sake	chiru	mimi	koori	酒	散る	耳	氷	さけ	ちる	みみ	こおり
jiki	shinu	shouji	soto	磁器	死ぬ	障子	外	じき	しぬ	しょうじ	そと
hosu	jikka	issai	ase	干す	実家	一切	汗	ほす	じっか	いっさい	あせ
haji	seki	osu	toru	恥	席	押す	取る	はじ	せき	おす	とる
nanji	jishin	roujin	hifu	何時	自身	老人	皮膚	なんじ	じしん	ろうじん	ひふ
itsu	yuki	naze	sanjyuu	何時	雪	何故	三十	いつ	ゆき	なぜ	さんじゆう
ana	imi	wake	kesu	穴	意味	訳	消す	あな	いみ	わけ	けす
ame	ie	tama	koro	雨	家	玉	頃	あめ	いえ	たま	ころ
natsu	neko	taka	aki	夏	猫	鷹	秋	なつ	ねこ	たか	あき
gunjin	naku	datte	hanbun	軍人	泣く	だって	半分	ぐんじん	なく	だって	はんぶん
yoshi	oba	geki	mondai	善し	伯母	劇	問題	よし	おば	げき	もんだい
tantei	nesshin	sonzai	mizu	探偵	熱心	存在	水	たんてい	ねっしん	そんざい	みず
heya	shiru	toshi	motto	部屋	知る	年	もっと	へや	しる	とし	もっと
katsu	mato	saigo	kuchi	勝つ	的	最後	口	かつ	まと	さいご	くち
shiri	aku	koe	hara	尻	悪	声	腹	しり	あく	こえ	はら
oku	taido	konna	mahi	置く	態度	こんな	麻痺	おく	たいど	こんな	まひ
kome	nana	ido	gojuu	米	七	井戸	五十	こめ	しち	いど	ごじゅう
densha	yonjuu	dame	nyoubou	電車	四十	駄目	女房	でんしゃ	よんじゅう	だめ	にょうぼう
haha	demo	kaki	haba	母	でも	垣	幅	はは	でも	かき	はば
shinshi	kaku	sensei	kane	紳士	書く	先生	金	しんし	かく	せんせい	かね
aite	ashi	negau	geisha	相手	足	願う	芸者	あいて	あし	ねがう	げいしゃ
kekkou	gake	yatto	yaru	結構	崖	やっと	遣る	けっこう	がけ	やっと	やる
denwa	kado	kekka	jama	電話	角	結果	邪魔	でんわ	かど	けっか	じゃま

Half-lists - Romanization				Half-lists - Kanji				Half-lists - Hiragana			
1B	2B	3B	4B	1B	2B	3B	4B	1B	2B	3B	4B
utsu	daijin	jiyuu	nanto	打つ	大臣	自由	何と	うつ	だいじん	じゆう	なんと
neesan	kakkou	kappa	donna	姉さん	恰好	河童	どんな	ねえさん	かっこう	かっぱ	どんな
mazu	tooru	zengo	tsuma	先ず	通る	前後	妻	まず	とおる	ぜんご	つま
nazo	sara	hebi	koukei	謎	皿	蛇	光景	なぞ	さら	へび	こうけい
kyoumi	iwa	baka	gogo	興味	岩	馬鹿	午後	きょうみ	いわ	ばか	ごご
kata	saka	ittai	haru	型	坂	一体	張る	かた	さか	いったい	はる
hone	shima	niisan	waza	骨	島	兄さん	業	ほね	しま	にいさん	わざ
futo	kyoufu	kesshin	uta	ふと	恐怖	決心	歌	ふと	きょうふ	けっしん	うた
eru	enryo	keru	saku	得る	遠慮	蹴る	咲く	える	えんりょ	ける	さく
sobo	kumo	tada	jitto	祖母	雲	只	じっと	そぼ	くも	ただ	じっと
yobu	taitei	kitto	genkou	呼ぶ	大抵	きっと	原稿	よぶ	たいてい	きっと	げんこう
saki	shiku	tooi	haigo	先	敷く	遠い	背後	さき	しく	とおい	はいご
uma	koko	shigai	shumi	馬	ここ	死骸	趣味	うま	ここ	しがい	しゅみ
aka	hachi	toori	choushi	赤	八	通り	調子	あか	はち	とおり	ちょうし
deha	sugu	ushi	take	では	直ぐ	牛	竹	では	すぐ	うし	たけ
shiro	machi	karu	oya	白	町	刈る	親	しろ	まち	かる	おや
tani	shintai	fune	shika	谷	身体	舟	鹿	たに	しんたい	ふね	しか
yome	ikken	waku	yaku	嫁	一軒	湧く	役	よめ	いっけん	わく	やく
jimu	chisai	hana	ningen	事務	小さい	花	人間	じむ	ちいさい	はな	にんげん
jiko	ari	dare	doko	自己	蟻	誰	何処	じこ	あり	だれ	どこ
kagen	keiken	otto	yado	加減	経験	夫	宿	かげん	けいけん	おっと	やど
yoku	kesa	kondo	shoku	よく	今朝	今度	食	よく	けさ	こんど	しょく
yama	yami	yoru	haku	山	闇	夜	吐く	やま	やみ	よる	はく
sora	kage	kago	ikka	空	影	籠	一家	そら	かげ	かご	いっか
mago	kenka	haka	kasa	孫	喧嘩	墓	傘	まご	けんか	はか	かさ

Table 9

Japanese Female Talker Bisyllabic Half-lists (25 Words) in Rank Order from Difficult to Easy

Half-lists - Romanization				Half-lists - Kanji				Half-lists - Hiragana			
1A	2A	3A	4A	1A	2A	3A	4A	1A	2A	3A	4A
kyoufu	geisha	sumi	koko	恐怖	芸者	隅	ここ	きょうふ	げいしゃ	すみ	ここ
kane	tane	shika	ie	金	種	鹿	家	かね	たね	しか	いえ
sugu	tsuma	enryo	zengo	直ぐ	妻	遠慮	前後	すぐ	つま	えんりょ	ぜんご
mago	toori	ito	naku	孫	通り	糸	泣く	まご	とおり	いと	なく
kyoumi	fumu	nanto	shinu	興味	踏む	何と	死ぬ	きょうみ	ふむ	なんと	しぬ
roujin	niku	ushi	itsu	老人	肉	牛	何時	ろうじん	にく	うし	いつ
gogo	nanji	kiku	waku	午後	何時	聞く	湧く	ごご	なんじ	きく	わく
kakkou	daijin	raku	toshi	恰好	大臣	楽	年	かっこう	だいじん	らく	とし
uma	sonzai	yoshi	shinshi	馬	存在	善し	紳士	うま	そんざい	よし	しんし
keiken	hachi	taitei	doumo	経験	八	大抵	どうも	けいけん	はち	たいてい	どうも
karu	katsu	kagen	uta	刈る	勝つ	加減	歌	かる	かつ	かげん	うた
yami	utsu	nami	yatto	闇	打つ	波	やっと	やみ	うつ	なみ	やっと
deha	jishin	aite	ari	では	自身	相手	蟻	では	じしん	あいて	あり
yobu	heya	ningen	negau	呼ぶ	部屋	人間	願う	よぶ	へや	にんげん	ねがう
nazo	kesshin	hairu	mimi	謎	決心	入る	耳	なぞ	けっしん	はいる	みみ
otto	choushi	yuki	shumi	夫	調子	雪	趣味	おっと	ちょうし	ゆき	しゅみ
migi	ikken	hanbun	saru	右	一軒	半分	去る	みぎ	いっけん	はんぶん	さる
sayou	taido	kabe	kappa	作用	態度	壁	河童	さよう	たいど	かべ	かっぱ
dono	kumo	doko	hone	どの	雲	何処	骨	どの	くも	どこ	ほね
yonjuu	aku	tooru	sanjyuu	四十	悪	通る	三十	よんじゅう	あく	とおる	さんじゆう
kesa	motto	horu	mahi	今朝	もっと	掘る	麻痺	けさ	もっと	ほる	まひ
koori	yome	datte	tada	氷	嫁	だって	只	こおり	よめ	だって	ただ
jama	douse	ashi	donna	邪魔	どうせ	足	どんな	じゃま	どうせ	あし	どんな
sora	kasa	yama	mondai	空	傘	山	問題	そら	かさ	やま	もんだい
yoru	neko	kado	ase	夜	猫	角	汗	よる	ねこ	かど	あせ

Half-lists - Romanization				Half-lists - Kanji				Half-lists - Hiragana			
1B	2B	3B	4B	1B	2B	3B	4B	1B	2B	3B	4B
mina	jikka	shima	kitto	皆	実家	島	きっと	みな	じっか	しま	きっと
sanpo	shiro	rouba	tatsu	散歩	白	老婆	立つ	さんぽ	しろ	ろうば	たつ
konna	haka	niisan	chiru	こんな	墓	兄さん	散る	こんな	はか	にいさん	ちる
jimu	kuchi	toku	sono	事務	口	得	其の	じむ	くち	とく	その
dake	jiyuu	iwa	michi	丈	自由	岩	道	だけ	じゆう	いわ	みち
genkou	ippou	saku	kusa	原稿	一方	咲く	草	げんこう	いっぽう	さく	くさ
dame	haba	osu	kekka	駄目	幅	押す	結果	だめ	はば	おす	けっか
tani	shiri	gunjin	tama	谷	尻	軍人	玉	たに	しり	ぐんじん	たま
hifu	kenka	eru	mazu	皮膚	喧嘩	得る	先ず	ひふ	けんか	える	まず
waza	oku	tantei	koro	業	置く	探偵	頃	わざ	おく	たんてい	ころ
mato	hana	fune	hara	的	花	舟	腹	まと	はな	ふね	はら
take	yado	neesan	mayu	竹	宿	姉さん	眉	たけ	やど	ねえさん	まゆ
natsu	kaku	hosu	hebi	夏	書く	干す	蛇	なつ	かく	ほす	へび
toru	ikka	chisai	shouji	取る	一家	小さい	障子	とる	いっか	ちいさい	しょうじ
mizu	shoku	nesshin	haku	水	食	熱心	吐く	みず	しょく	ねっしん	はく
kekkou	haha	naze	densha	結構	母	何故	電車	けっこう	はは	なぜ	でんしゃ
tooi	saigo	ana	kage	遠い	最後	穴	影	とおい	さいご	あな	かげ
oya	ido	gake	nyoubou	親	井戸	崖	女房	おや	いど	がけ	にょうぼう
haji	aki	byounin	kome	恥	秋	病人	米	はじ	あき	びょうにん	こめ
denwa	kaki	baka	demo	電話	垣	馬鹿	でも	でんわ	かき	ばか	でも
aka	issai	koe	sensei	赤	一切	声	先生	あか	いっさい	こえ	せんせい
oba	nana	kago	machi	伯母	七	籠	町	おば	しち	かご	まち
yaru	gojuu	yoku	kondo	遣る	五十	よく	今度	やる	ごじゅう	よく	こんど
soto	kawa	sobo	yaku	外	皮	祖母	役	そと	かわ	そぼ	やく
nando	ame	dare	wake	何度	雨	誰	訳	なんど	あめ	だれ	わけ

male and female talker recordings. The logistic regression slopes and intercepts for each list and half-list are presented in Table 10 (male talker) and Table 11 (female talker). The regression slopes and intercepts were inserted into Equation 2 to calculate percentage of correct recognition for each list as a function of intensity to construct psychometric functions. The smooth, unadjusted psychometric functions for lists and half-lists are found in Figure 4 with the male talker on the right and the female talker on the left. The psychometric functions for the 4 lists are presented in the top panels and the half-lists are presented in the bottom panels.

By inserting the regression slopes and intercepts and intensity level into Equation 2, it is possible to predict the percentage of correct recognition at any specified intensity level. Percentage of correct speech discrimination was predicted for each of the bisyllabic lists and half-lists for a range of -8 to 40 dB HL in 2 dB increments to allow calculation of psychometric functions. The threshold (presentation intensity required for 50% speech discrimination performance), the slope at threshold, and the slope from 20 to 80% were calculated for the bisyllabic lists and half-lists by inserting the desired proportions into Equation 3. These data for each list and half-list are presented in Table 10 (male) and Table 11 (female).

Once the lists and half-lists were created a two-way Chi-Square (χ^2) analysis found that there were no statistically significant differences among the 4 full-lists for the male and female talkers, $\chi^2(3) = 0.26$, $p = 0.968$, and $\chi^2(3) = 2.48$, $p = 0.478$, respectively. There were also no significant differences among the half-lists for the male and female talkers, $\chi^2(3) = 0.83$, $p = 0.997$, and $\chi^2(3) = 8.21$, $p = 0.314$ respectively. Interactions between intensity and list were not significant, indicating no differences among the

Table 10

Mean Performance of Japanese Male Talker Bisyllabic Lists and Half-lists

List/Half-list	a[a]	b[b]	Slope at at 50%[c]	Slope from 20 to 80%[d]	Threshold[e]	ΔdB[f]
1	2.7523	-0.2361	5.9	5.1	11.7	2.2
2	2.6295	-0.2277	5.7	4.9	11.5	2.1
3	2.7658	-0.2372	5.9	5.1	11.7	2.2
4	2.7320	-0.2364	5.9	5.1	11.6	2.1
M	2.7199	-0.2343	5.9	5.1	11.6	2.1
Minimum	2.6295	-0.2372	5.7	4.9	11.5	2.1
Maximum	2.7658	-0.2277	5.9	5.1	11.7	2.2
Range	0.1363	0.0095	0.2	0.2	0.1	0.1
SD	0.0619	0.0045	0.1	0.1	0.1	0.1
1A	2.6295	-0.2277	5.7	4.9	11.5	2.1
1B	2.8864	-0.2453	6.1	5.3	11.8	2.3
2A	2.6941	-0.2318	5.8	5.0	11.6	2.2
2B	2.5725	-0.2240	5.6	4.8	11.5	2.0
3A	2.6797	-0.2319	5.8	5.0	11.6	2.1
3B	2.8570	-0.2428	6.1	5.3	11.8	2.3
4A	2.6941	-0.2318	5.8	5.0	11.6	2.2
4B	2.7691	-0.2408	6.0	5.2	11.5	2.0
M	2.7228	-0.2345	5.9	5.1	11.6	2.1
Minimum	2.5725	-0.2453	5.6	4.8	11.5	2.0
Maximum	2.8864	-0.2240	6.1	5.3	11.8	2.3
Range	0.3139	0.0212	0.5	0.5	0.3	0.3
SD	0.1081	0.0076	0.2	0.2	0.1	0.1

[a]*a* = regression intercept. [b]*b* = regression slope. [c]Psychometric function slope (%/dB) at 50% was calculated from 49.999 to 50.001%. [d]Psychometric function slope (%/dB) from 20-80%. [e]Intensity required for 50% intelligibility. [f]Change in intensity required to adjust the threshold of the list to the mean threshold for male and female lists (9.46 dB HL)

Table 11

Mean Performance of Japanese Female Talker Bisyllabic Lists and Half-lists

List/Half-list	a[a]	b[b]	Slope at at 50%[c]	Slope from 20 to 80%[d]	Threshold[e]	ΔdB[f]
1	1.6730	-0.2244	5.6	4.9	7.5	-2.0
2	1.4441	-0.2003	5.0	4.3	7.2	-2.3
3	1.4805	-0.2035	5.1	4.4	7.3	-2.2
4	1.5180	-0.2067	5.2	4.5	7.3	-2.1
M	1.5289	-0.2087	5.2	4.5	7.3	-2.1
Minimum	1.4441	-0.2244	5.0	4.3	7.2	-2.3
Maximum	1.6730	-0.2003	5.6	4.9	7.5	-2.0
Range	0.2289	0.0240	0.6	0.5	0.2	0.2
SD	0.1007	0.0108	0.3	0.2	0.1	0.1
1A	1.7235	-0.2221	5.6	4.8	7.8	-1.7
1B	1.6249	-0.2271	5.7	4.9	7.2	-2.3
2A	1.3692	-0.1925	4.8	4.2	7.1	-2.4
2B	1.5250	-0.2089	5.2	4.5	7.3	-2.2
3A	1.6379	-0.2146	5.4	4.6	7.6	-1.8
3B	1.3378	-0.1937	4.8	4.2	6.9	-2.6
4A	1.4738	-0.1952	4.9	4.2	7.6	-1.9
4B	1.5730	-0.2205	5.5	4.8	7.1	-2.3
M	1.5331	-0.2093	5.2	4.5	7.3	-2.1
Minimum	1.3378	-0.2271	4.8	4.2	6.9	-2.6
Maximum	1.7235	-0.1925	5.7	4.9	7.8	-1.7
Range	0.3857	0.0346	0.9	0.7	0.9	0.9
SD	0.1341	0.0139	0.3	0.3	0.3	0.3

[a]*a* = regression intercept. [b]*b* = regression slope. [c]Psychometric function slope (%/dB) at 50% was calculated from 49.999 to 50.001%. [d]Psychometric function slope (%/dB) from 20-80%. [e]Intensity required for 50% intelligibility. [f]Change in intensity required to adjust the threshold of the list to the mean threshold for male and female lists (9.46 dB HL)

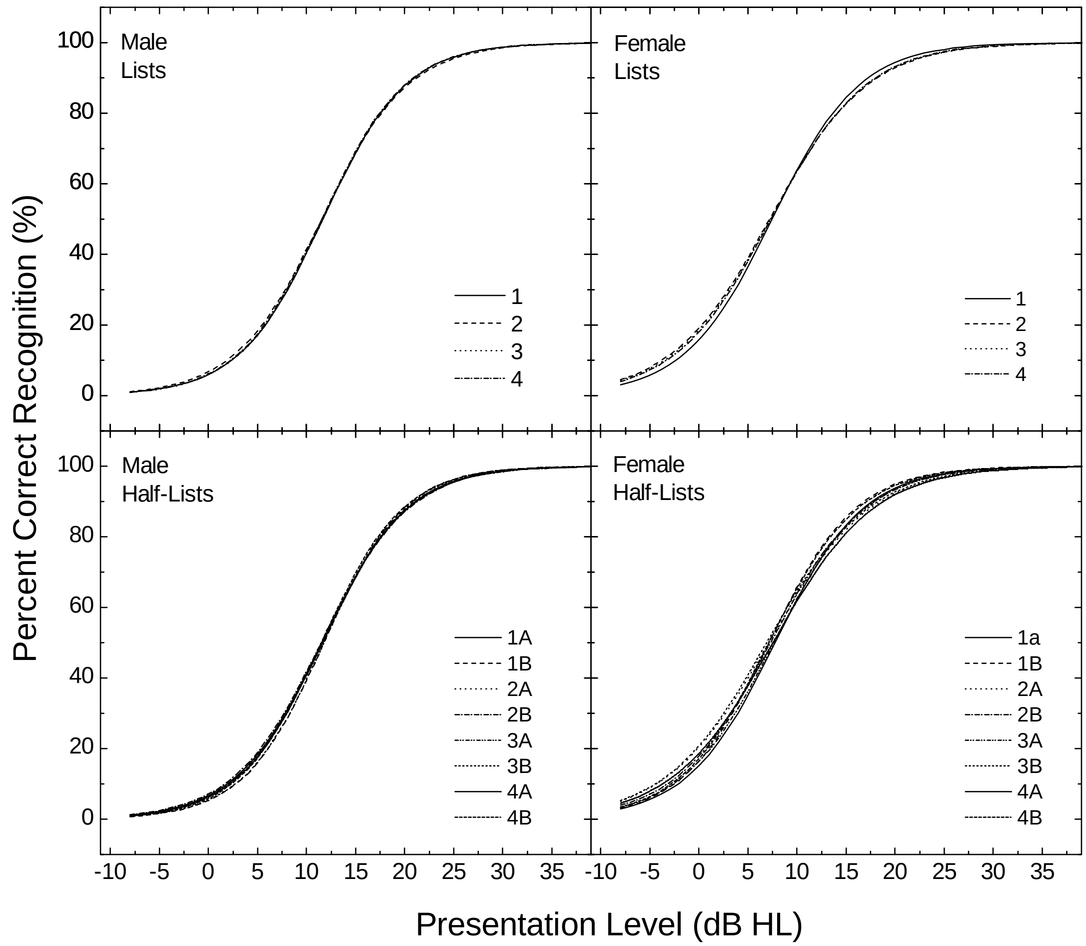

Figure 4.

Psychometric functions for the four Japanese bisyllabic lists and eight half-lists for male talker and female talker recordings before intensity adjustments.

psychometric function slopes for the lists of half-lists; male lists: $\chi^2(3) = 1.65$, $p = 0.648$, female lists: $\chi^2(3) = 2.93$, $p = 0.403$, male half-lists: $\chi^2(3) = 2.58$, $p = 0.021$, female half-lists: $\chi^2(3) = 4.06$, $p = 0.773$. There were no statistically significant differences among lists or half-lists, intensity level adjustments were made digitally using Sadie Disk Editor software (Studio Audio & Video Ltd., 2004) in an attempt to increase the psychometric equivalency of the lists and half-lists. The intensity of each word in the 8 bisyllabic lists (4 male & 4 female) and the 16 half-lists (8 male & 8 female) was digitally adjusted so that the 50% threshold of each list was equal to the midpoint (9.46 dB HL) between the mean threshold of the 8 male half-lists and the mean threshold of the 8 female half-lists. The psychometric functions for the intensity adjusted lists are shown in Figure 5 with the male talker on the left, female talker on the right, lists on the top and half-lists on the bottom. The comparison of all lists before and after adjustment for both male and female can be found in Figure 6 which shows that the female unadjusted lists were easier to hear then the male unadjusted lists. After intensity adjustments the predicted list performance was almost identical for the male and female talkers.

Discussion

The main purposes of this study were to (a) develop a homogeneous subset of Japanese trisyllabic words for use in measuring the SRT and (b) create a set of homogeneous Japanese bisyllabic word lists for use in measuring speech discrimination.

The homogeneity of the subset of trisyllabic words can be seen by referring to Figure 1E-F, which contains the predicted psychometric functions for the 25 selected trisyllabic words after intensity adjustment. These 25 male and female talker trisyllabic words as spoken by the male talker and the female talker are much more homogeneous

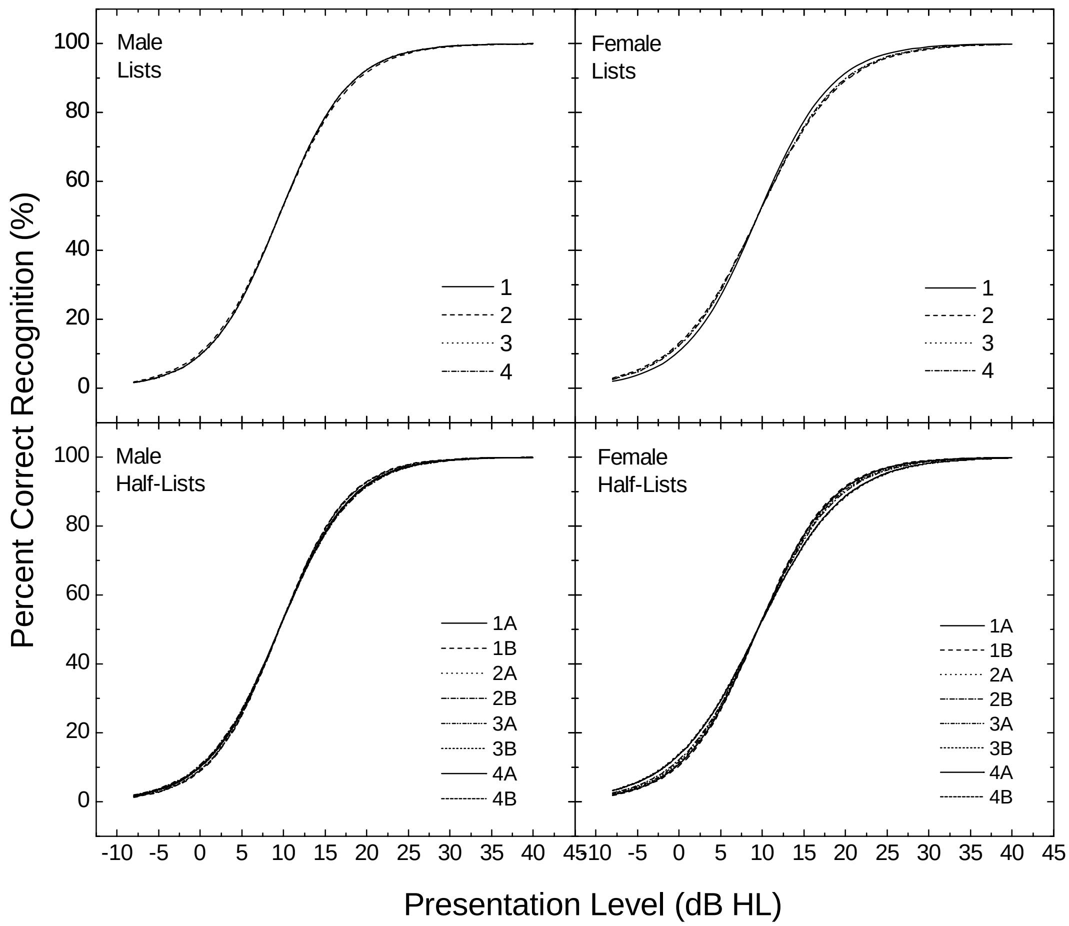

Figure 5.

Psychometric functions for the four Japanese bisyllabic lists and eight half-lists for male talker and female talker recordings after intensity adjustments to produce 50% performance at 9.46 dB HL.

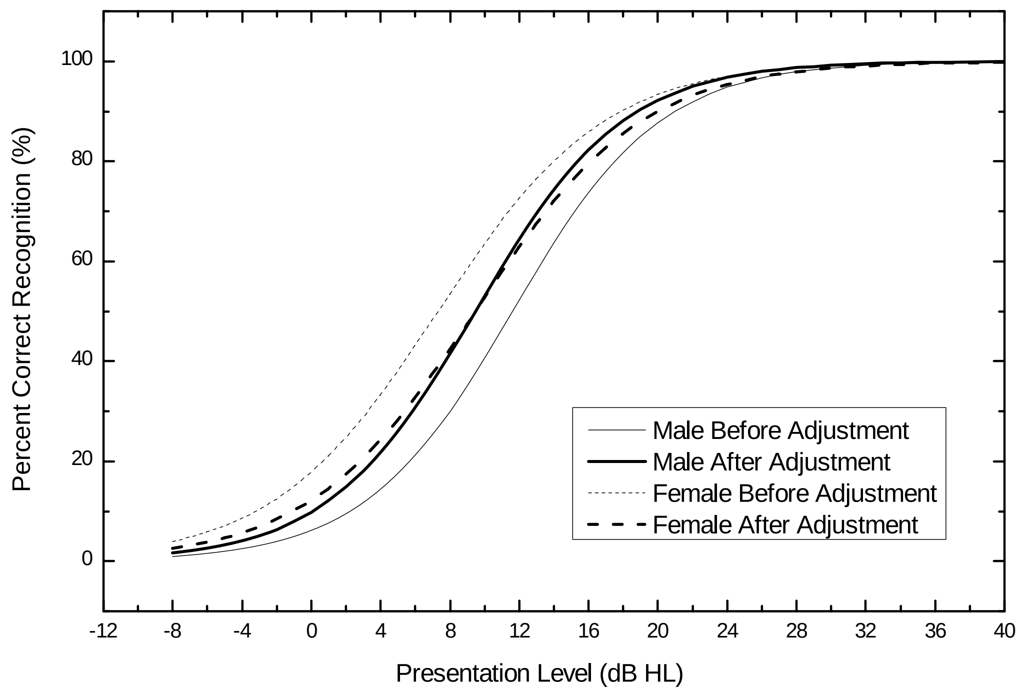

Figure 6.

Mean psychometric functions for male and female Japanese talker bisyllabic lists before and after intensity adjustment.

with respect to audibility and psychometric function slope then the original unadjusted words.

The slopes at 50% for the 25 trisyllabic words encompassed a range of 7.7-13.4%/dB (*M* = 10.3%/dB) for the male talker and a range of 7.6-11.3%/dB (*M* = 8.7%/dB) for the female talker. The psychometric function slopes for the Japanese trisyllabic words, for both the male and the female talker, are in close agreement with means for SRT materials that have been reported in other languages. The mean psychometric function slopes for English spondaic words ranges from 7.2%/dB (Wilson & Strouse, 1999) to 12%/dB (Beattie, Svihovec et al., 1975). Other studies have found slopes of psychometric functions for English spondaic words to be 10%/dB (Young et al., 1982; Hudgins et al., 1947). The mean psychometric function slopes for Polish bisyllabic SRT materials was 10.1%/dB for the male talker and 9.8%/dB for the female talker (Harris et al., 2004a). For Korean bisyllabic SRT materials the mean psychometric function slope was found to be 10.5%/dB for the male talker and 9.3%/dB for the female talker (Harris et al., 2003a). The mean slopes for Japanese trisyllabic words of 10.3%/dB (male) and 8.7%/dB (female) are in good agreement with slopes for materials developed in other languages.

As can be seen in Tables 6 (male) and 7 (female), psychometric function slopes at the 50% location for the bisyllabic lists and half-lists ranged from 5.6-6.1%/dB (*M* = 5.9%/dB) for the male recordings and from 4.8-5.7%/dB (*M* = 5.2%/dB) for the female recordings. The psychometric function slopes from 20 to 80% for the bisyllabic lists and half-lists ranged from 4.8-5.3%/dB (*M* = 5.1%/dB) for the male recordings and from 4.2-4.9%/dB (*M* = 4.5%/dB) for the female recordings. A Chi-square analysis was used to identify any statistically significant differences among bisyllabic full and half-lists. No significant differences were found among the 4 full-lists and the 8 half-lists. The mean slopes of psychometric functions for English speech discrimination materials are very comparable. Beattie, Edgerton et al. (1977) found a mean slope of 4.2%/dB for NU-6 word lists and a mean slope of 4.6%/dB for the CID W-22 word lists. Korean monosyllabic lists name a mean slope from 20 to 80% of 4.4%/dB for the male talker and 4.4%/dB for the female talker (Harris et al., 2003b). The mean psychometric function slope for Polish monosyllabic speech discrimination lists from 20 to 80% was found to be 5.0%/dB for the male talker and 5.1%/dB for the female talker (Harris et al., 2004b). Japanese speech discrimination materials were found to have mean slopes of 5.9%/dB (male) and 5.2%/dB (female) which are in close proximity with slopes for materials developed in other languages. According to the bisyllabic results speech discrimination testing should be conducted at 32 dB HL or higher.

Much more research is needed in the area of developing of Japanese speech audiometry materials. Additional research with the Japanese trisyllabic SRT words developed in this project should be done to compare the obtained SRT with the PTA of normally hearing and the hearing impaired populations. Future research needs to be conducted in the area of speech discrimination to examine Japanese list and half-list equivalency for individuals with varying types and degrees of hearing impairment. Also, lists developed in this study using bisyllabic and trisyllabic words could be compared with those on the Audiology Japan CD using monosyllabic nonsense words. Further research could also be conducted to develop speech audiometry materials for use with children and for assessment of cochlear implants and central auditory processing capabilities.

In conclusion, this study (a) identified and developed recordings of trisyllabic words to be used to measure SRT and (b) bisyllabic words to include in speech discrimination lists (50 words) and half-lists (25 words). The homogeneous set of 25 trisyllabic words developed in this study can be utilized to measure the SRT in individuals whose native language is Japanese. These trisyllabic words are familiar and homogeneous with respect to audibility and psychometric function slope.

This research also resulted in the development of digitally recorded bisyllabic Japanese speech discrimination lists and half-lists of familiar words. These lists and half-lists are homogeneous with respect to audibility and psychometric function slope for both the male and female talker recordings. These lists can be used to evaluate speech discrimination in individuals whose native language is Japanese. The trisyllabic words are contained on tracks 2 and 3 of the *Brigham Young University Japanese Speech Audiometry Materials CD (Disc 1.0)* in addition to the bisyllabic lists and half-lists for both the male and female talkers which are contained on tracks 4-15 (Harris, Crawford, & Mastny, 2004). The CD also includes instructions for routine audiometric evaluation (tracks 20-23). This CD's contents are included in Appendix D.

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Appendix A

Informed Consent

Research Participation Form

Participant:__________________________Age:_______

You are asked to participate in a research study sponsored by the Department of Audiology and Speech Language Pathology at Brigham Young University, Provo, Utah. The faculty director of this research is Richard W. Harris, Ph.D. Students in the Audiology and Speech-Language Pathology program may assist in data collection.

This research project is designed to evaluate a word list recorded using improved digital techniques. You will be presented with this list of words at varying levels of intensity. Many will be very soft, but none will be uncomfortably loud to you. You may also be presented with this list of words in the presence of a background noise. The level of this noise will be audible but never uncomfortably loud to you. This testing will require you to listen carefully and repeat what is heard through earphones or loudspeakers. Before listening to the word lists, you will be administered a routine hearing test to determine that your hearing is normal and that you are qualified for this study.

It will take approximately two hours to complete the test. Testing will be broken up into 2 or 3 one hour blocks. Each subject will be required to be present for the entire time, unless prior arrangements are made with the tester. You are free to make inquiries at any time during testing and expect those inquiries to be answered.

As the testing will be carried out in standard clinical conditions, there are no known risks involved. Standard clinical test protocol will be followed to ensure that you will not be exposed to any unduly loud signals.

Names of all subjects will be kept confidential to the investigators involved in the study.

Participation in the study is a voluntary service and no payment of monetary reward of any kind is possible or implied.

You are free to withdraw from the study at any time without any penalty, including penalty to future care you may desire to receive from this clinic.

If you have any questions regarding this research project you may contact Dr. Richard W. Harris, 131 TLRB, Brigham Young University, Provo, Utah 84602; phone (801) 422-6460. If you have any questions regarding your rights as a participant in a research project you may contact Dr. Shane Schulthies, Chair of the Institutional Review Board, 122A RB, Brigham Young University, Provo, UT 84602; phone (801) 422-5490.

YES: I agree to participate in the Brigham Young University research study mentioned above. I confirm that I have read the preceding information and disclosure. I hereby give my informed consent for participation as described.

____________________________ _______________________

Signature of Participant Date

____________________________ _______________________

Signature of Witness Date

Appendix B

Evaluation Sheet for Talkers (English)

Name of Talker ____________________

• Pronunciation	1	2	3	4	5	6	7	8	9	10
• Fluency	1	2	3	4	5	6	7	8	9	10
• Easy Listening	1	2	3	4	5	6	7	8	9	10
• Good for a CD	1	2	3	4	5	6	7	8	9	10

Appendix C

Evaluation Sheet for Talkers (Japanese)

テープの話者を次にあげる特性ごとに評価してください。

１＝最も良い…２３４５６７８９…１０＝最も悪い

話者____________

・発音	１	２	３	４	５	６	７	８	９	１０
・流暢さ	１	２	３	４	５	６	７	８	９	１０
・聞きやすさ	１	２	３	４	５	６	７	８	９	１０

この話者は全体として、

	１	２	３	４	５	６	７	８	９	１０

Appendix D

Description of BYU Japanese Speech Audiometry Materials CD

Track 1 1 kHz calibration tone.

Track 2 Trisyllabic words for use in measuring the SRT in alphabetical order for familiarization purposes.

Track 3 Trisyllabic words for use in measuring the SRT in random order, repeated in blocks for a total duration of 5 minutes.

Track 4 Speech Discrimination List 1 – 50 bisyllabic words in random order.

Track 5 Speech Discrimination List 2 – 50 bisyllabic words in random order.

Track 6 Speech Discrimination List 3 – 50 bisyllabic words in random order.

Track 7 Speech Discrimination List 4 – 50 bisyllabic words in random order.

Track 8 Speech Discrimination List 1A – 25 bisyllabic words in random order.

Track 9 Speech Discrimination List 1B – 25 bisyllabic words in random order.

Track 10 Speech Discrimination List 2A – 25 bisyllabic words in random order.

Track 11 Speech Discrimination List 2B – 25 bisyllabic words in random order.

Track 12 Speech Discrimination List 3A – 25 bisyllabic words in random order.

Track 13 Speech Discrimination List 3B – 25 bisyllabic words in random order.

Track 14 Speech Discrimination List 4A – 25 bisyllabic words in random order.

Track 15 Speech Discrimination List 4B – 25 bisyllabic words in random order.

Track 16 言葉が聞こえる限界閾

このテストでは、どこまで弱い音を聞いてそれをくり返せるか測定します。いろいろな音量の言葉を聴いて、その度にそれをくり返して下さい。非常にかすかな音であってもくり返してください。推測しても構いません。もし言葉が理解できず、推測もできなければそのまま黙って次の言葉を待って下さい。

Instructions for Speech Reception Threshold: "The purpose of this test is to determine the softest (faintest) level at which you can hear and repeat words. You are going to hear a series of words that may vary in volume. Each time you hear a word, just repeat it. Repeat the words even if they sound very soft (faint). You may have to guess. If you did not understand the word and you are not able to guess please remain silent and wait for the next word."

Track 17 発話識別検査（書くことによる応答）

このテストでは、一定の聴解レベル発せられる言葉をどのくらい理解できるかを測定します。言葉が聞こえる度にそれをただくり返して下さい。言葉が確かでない時は推

測して下さい。もし言葉が理解できず、推測もできなければ空欄に線を引いて（ー）次の言葉を待って下さい。

Instructions for Speech Discrimination Testing (written response): “The purpose of this test is to determine how well you can understand words when they are presented at a constant level. Each time you hear a word, please write it down on the paper provided. If you are unsure of what the word was you may have to guess. If you did not understand the word, and you are not able to guess, please draw a line (dash) in the space provided and wait for the next word.”

Track 18 発話識別検査（口頭での応答）

このテストでは、片方の耳で雑音を、そしてもう片方の耳で言葉を聞きます。できる限り雑音を無視してその言葉だけを聞くようにして下さい。言葉が聞こえる度にそれを口頭で繰り返して下さい。言葉が確かでない時は推測して下さい。言葉が理解できず、推測もできなければ、そのまま黙って次の言葉を待って下さい。

Instructions for Speech Discrimination Testing with masking in the non-test ear (verbal response): “During this part of the test you will hear a noise in one ear and words in the other. Do your best to ignore the noise and listen only to the words. Each time you hear a word, please repeat it. If you are unsure of what the word was you may have to guess. If you did not understand the word, and you are not able to guess, please remain silent and wait for the next word.”

Track 19 発話識別検査（書くことによる応答）

このテストでは、片方の耳で雑音を、そしてもう片方の耳で言葉を聞きます。できる限り雑音を無視してその言葉だけを聞くようにして下さい。言葉が聞こえる度にそれを用紙に書いて下さい。言葉が確かでない時は推測しても構いません。言葉が理解できず、推測もできなければ、空欄に線を引いて（ー）次の言葉を待って下さい。

Instructions for Speech Discrimination Testing with masking in the non-test ear (written response): “During this part of the test you will hear a noise in one ear and words in the other. Do your best to ignore the noise and listen only to the words. Each time you hear a word, please write it down on the paper provided. If you are unsure of what the word was you may have to guess. If you did not understand the word, and you are not able to guess, please draw a line (dash) in the space provided and wait for the next word.”

Track 20 純音聴力検査（挙手による応答）

このテストでは、どこまで弱い音が聞こえるかを測定します。一連の音を、最初は片方の耳で、それからもう片方の耳で聞きます。音の中には容易に聞こえるものもありますが、ほとんどは非常にかすかで、聞くには弱すぎる音もあります。ですから音が聞こえたら手を挙げて、その音が聞こえているうちは手を挙げ続けてください。音が消えたらすぐに手をおろして下さい。どんなにかすかな音でも聞こえる度に手を挙げるようにして下さい。

Instructions for Pure-Tone Audiometry (hand raising response): “The purpose of this test is to determine the softest (faintest) sounds you can hear. You are going to hear a series of tones, first in one ear and then in the other. Some of the tones will be easy to hear, but most of them will be very faint, and some of them may be too soft to hear. Your job is to raise your hand every time you hear a tone and keep it up for as long as you hear the tone. Put your hand down quickly when the tone goes off. Remember, raise your hand every time you hear a tone, no matter how soft (faint) it is.”

Track 21　純音聴力検査（ボタンによる応答）

このテストでは、どこまで弱い音が聞こえるかを測定します。一連の音を、最初は片方の耳で、それからもう片方の耳で聞きます。音の中には容易に聞こえるものもありますが、ほとんどは非常にかすかで、聞くには弱すぎる音もあります。ですから音が聞こえたらボタンを押して、その音が聞こえているうちはボタンを押し続けて下さい。音が消えたらすぐにボタンを離して下さい。どんなにかすかな音でも聞こえる度にボタンを押して下さい。

Instructions for Pure-Tone Audiometry (button pressing response): “The purpose of this test is to determine the softest (faintest) sounds you can hear. You are going to hear a series of tones, first in one ear and then in the other. Some of the tones will be easy to hear, but most of them will be very faint, and some of them may e too soft to hear. Your job is to press the button every time you hear a tone and keep it pressed for as long as you hear the tone. Release the button quickly when the tone goes off. Remember, press the button every time you hear a tone, no matter how soft (faint) it is.”

Track 22　検査をしない方の耳で雑音を伴っての純音聴力検査（挙手による応答）

このテストでは、雑音を伴った音を聞きます。その雑音のレベルはいろいろですが、雑音を無視して検査の音だけを聞いて下さい。音が聞こえたらすぐに手を挙げて、その音が聞こえている間は手を挙げ続けて下さい。音が消えたらすぐに手をおろして下さい。どんなにかすかな音でも、聞こえる度に手を挙げるようにして下さい。

Instructions for Pure-Tone Audiometry with masking in non-test ear (hand raising response): “During this part of the test you will be listening for a tone in the presence of a background noise. The level of the noise may vary. Please ignore the noise and listen only for the tone. When you hear the tone, immediately raise your hand and keep it up for as long as you hear the tone. Put your hand down quickly when the tone goes off. Remember, raise your hand every time you hear a tone, no matter how soft (faint) it is.”

Track 23　検査をしない方の耳で雑音を伴っての純音聴力検査（ボタンによる応答）

このテストでは、雑音を伴った音を聞きます。その雑音のレベルはいろいろですが、雑音を無視して検査の音だけを聞いて下さい。音が聞こえたらすぐにボタンを押して、その音が聞こえている間はボタンを押し続けて下さい。音が消えたらすぐにボタンを押すのをやめて下さい。どんなにかすかな音でも、聞こえる度にボタンを押すようにして下さい。

Instructions for Pure-Tone Audiometry with masking in the non-test ear (button pressing response): “During this part of the test you will be listening for a tone in the presence of a background noise. The level of the noise may vary. Please ignore the noise and listen only for the tone. When you hear the tone, immediately press the button and keep it pressed for as long as you hear the tone. Put your hand down quickly when the tone goes off. Remember, press the button every time you hear a tone, no matter how soft (faint) it is.”